VOL. XXXV. No. 11. NOVEMBER, 1957

2 - MAY 5
Copy 1967

THE STRUCTURAL ENGINEER

THE JOURNAL OF THE
INSTITUTION OF STRUCTURAL ENGINEERS

Presidential Address: The Way of Research
by Professor Sir Alfred Pugsley, O.B.E.

Structural Features of the New Binns Store in Middlesbrough
by F. R. Bullen (Hon. Treasurer)

The Relationship of the Architect and the Structural Engineer
by L. A. Chackett

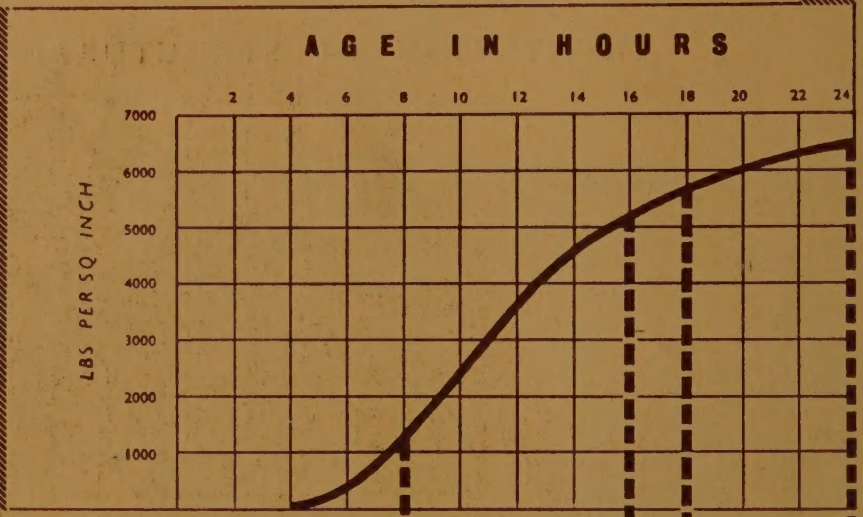
Universal Beams and their Application
by S. Barlow (Member) and G. Foster

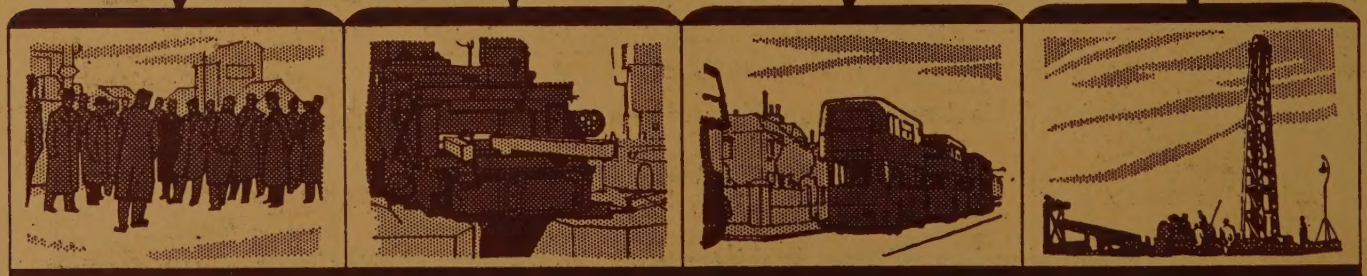
FOUR SHILLINGS

NO OTHER CEMENT GIVES YOU THIS TIME/STRENGTH ADVANTAGE

Only Aluminous Cement will provide concrete which reduces waiting time to such a low minimum. By careful planning, maintenance work, such as floor repairs, or the installation of new machines, can be accomplished over the week-end, or even overnight, without interruption of production. Keep a stock of Ciment Fondu—against these urgent repairs.

Concrete in hours not days





Ready to walk upon at eight hours.

Machinery can be erected upon foundations at 16 hours.

Road repairs can be re-opened to traffic at 18 hours.

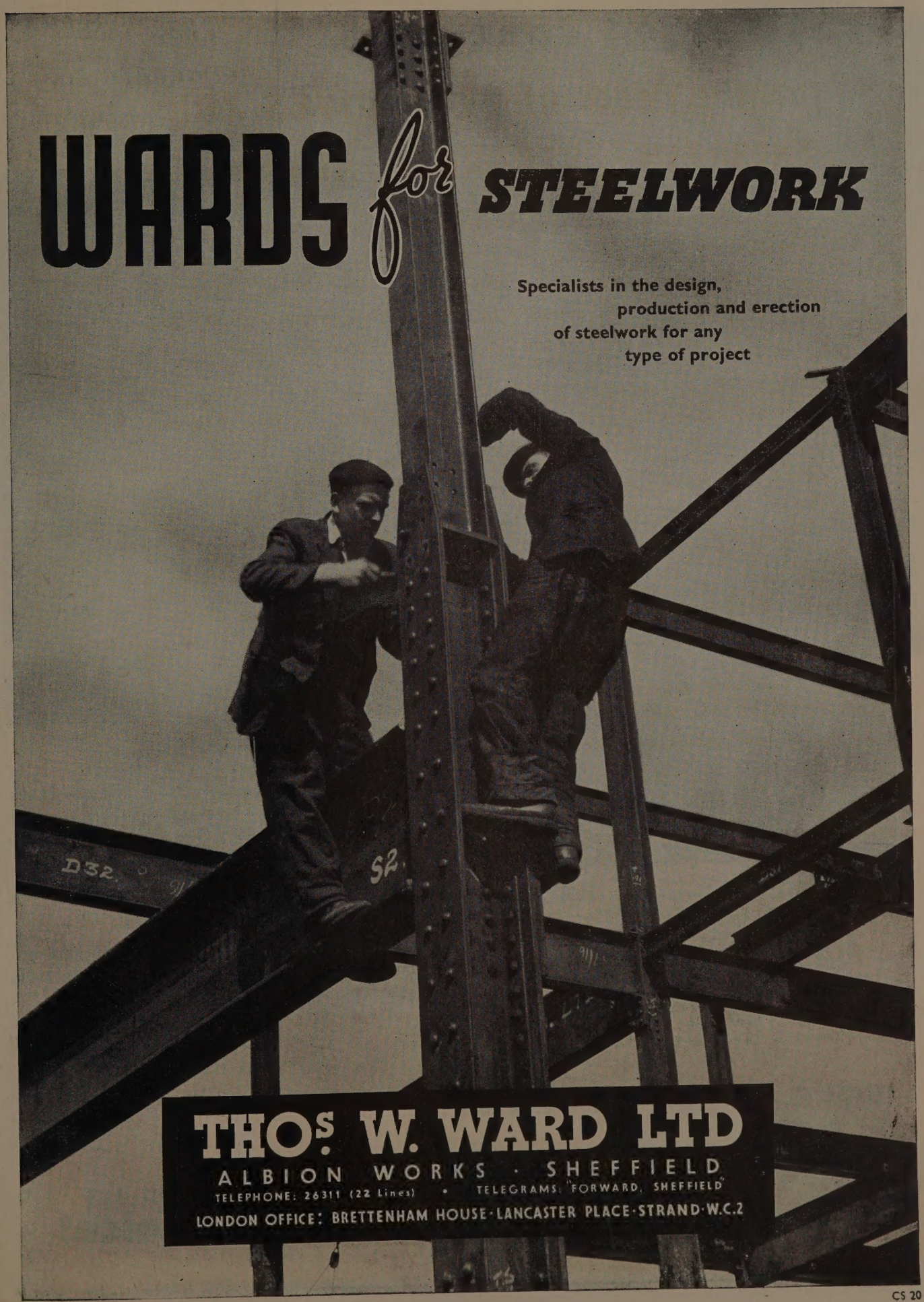
Piles can be driven at 24 hours.

Write for copy of interesting leaflet:—
"DO THAT CONCRETING JOB OVER THE WEEK-END"

LAFARGE ALUMINOUS CEMENT COMPANY LIMITED
73 BROOK STREET, LONDON, W.1. Tel: MAYFAIR 8546

CIMENT FONDU
Regd Trade Mark
ALUMINOUS CEMENT

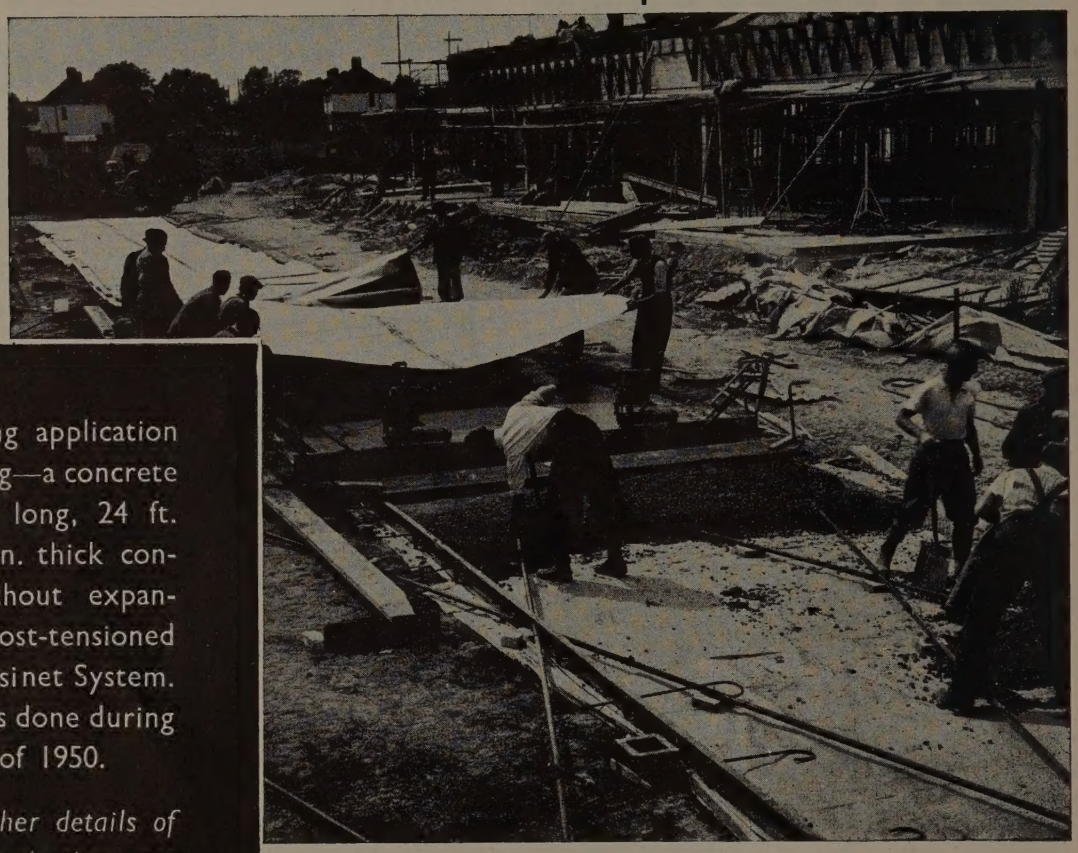
APS-1325


WARDS for STEELWORK
Specialists in the design,
production and erection
of steelwork for any
type of project
THOS. W. WARD LTD
ALBION WORKS · SHEFFIELD
TELEPHONE: 26311 (22 Lines) · TELEGRAMS: "FORWARD, SHEFFIELD"
LONDON OFFICE: BRETTENHAM HOUSE · LANCASTER PLACE · STRAND · W.C.2
CS 20

Prestressed concrete - for the roads of tomorrow?

PRESTRESSED CONCRETE ROAD

CRAWLEY INDUSTRIAL ESTATE



An interesting application of Prestressing—a concrete road 400 ft. long, 24 ft. wide and 6 in. thick constructed without expansion joint. Post-tensioned by The Freyssinet System. The work was done during the summer of 1950.

* *Some further details of this project and others are published in brochure form. Write for your copy now.*

Sponsor : Crawley Development Corporation, Chief Engineer at the Time : A. J. W. McIntosh, B.Sc., M.I.C.E., M.I.Mech.E.

Designers : Crawley Development Corporation with collaboration of the Prestressed Concrete Co., Ltd., The Road Research Laboratory and The County Councils of East and West Sussex.

Contractors : Willment Bros. Ltd., Twickenham.

Ever since prestressed concrete construction was first used in this country, designers, architects and civil engineers have specified "Wire by Johnsons." The reason is quality built up on early experimental work with those specialist designers who studied and worked in the Continental development of this new building technique.

Johnsons have a long record of "Firsts" including indented wire for greater bonding and coils of 8ft. diameter, from which the wire pays out straight.

wire was essential—

Johnsons the choice!

Richard Johnson & Nephew Ltd., Manchester, 11

Road bridge, Glen Quoich, Inverness-shire, part of the Garry Hydro-Electric Project. Consulting Engineers: Sir William Halcrow and Partners.

New bridge under construction at Conway, North Wales.

Steel Bridges

As builders of steel bridges, ARROL have long contributed to the improvement of communications. Abroad, present activities include the construction of a road bridge over the River Euphrates in Iraq, and the supply of steelwork for the Hunter River Bridge in New South Wales. At home, work is proceeding on the new bridge at Conway in North Wales, and a road bridge has been completed at Glen Quoich, Inverness-shire—an all welded structure of high tensile steel.

All types of Steel Framed Buildings; Fixed and Opening Bridges; Cranes and Mechanical Engineering work; Dock Gates; Sliding and Floating Caissons; Compressed Air Locks; Hydraulic Machinery; Pipe Lines, Surge Tanks, Sluices and other equipment for Hydro-Electric Projects.

SIR WILLIAM ARROL & CO LTD GLASGOW

Arrol

Steelwork by.....

Structural Steelwork in course of erection at the Modern New Factory for H. J. HEINZ Co. Ltd., at Kitt Green, near Wigan, (approx. 8,000 tons), for which we are the Nominated Sub-Contractors. Photograph shows the steelwork for the Production Building of the Contract.

Architects : Messrs. J. Douglass Mathews & Partners.
General Contractors : Messrs. A. Monk & Co. Ltd.

PEIRSON ..... **& COMPANY LIMITED**

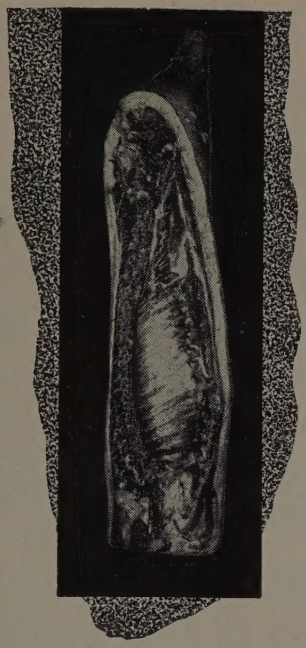
Structural Engineers & Contractors

Over eighty years accumulated experience in the design, fabrication and erection of every type of constructional steelwork, riveted or welded.

Personal attention is assured to all enquiries, and our advisory and designing staff is at your service to bring their skill and experience to your particular problem.

Gray's Inn Chambers, 20 High Holborn, London, W.C.I

TELEPHONE: **HOLBORN 2181** (PRIVATE BRANCH EXCHANGE) TELEGRAMS: **ALLEGRETTO, HOLB., LONDON**



the right cure for bacon is oak chippings . . .

the right cure for concrete is "Ritecure"

Illustrating the one-man spraying operation.

As tested and proved under all climatic conditions

One application of RITECURE MEMBRANE CURING material provides an impervious film controlling evaporation throughout the curing period of 28 days. The colourless liquid (applied while concrete is wet) has a temporary colour indicator added to aid application and inspection but this disappears after a few hours. One gallon covers approximately 30 square yards of concrete. Complete in itself, RITECURE requires no wetting down or covering and provides increased compressive strength and resistance to surface wear.

★

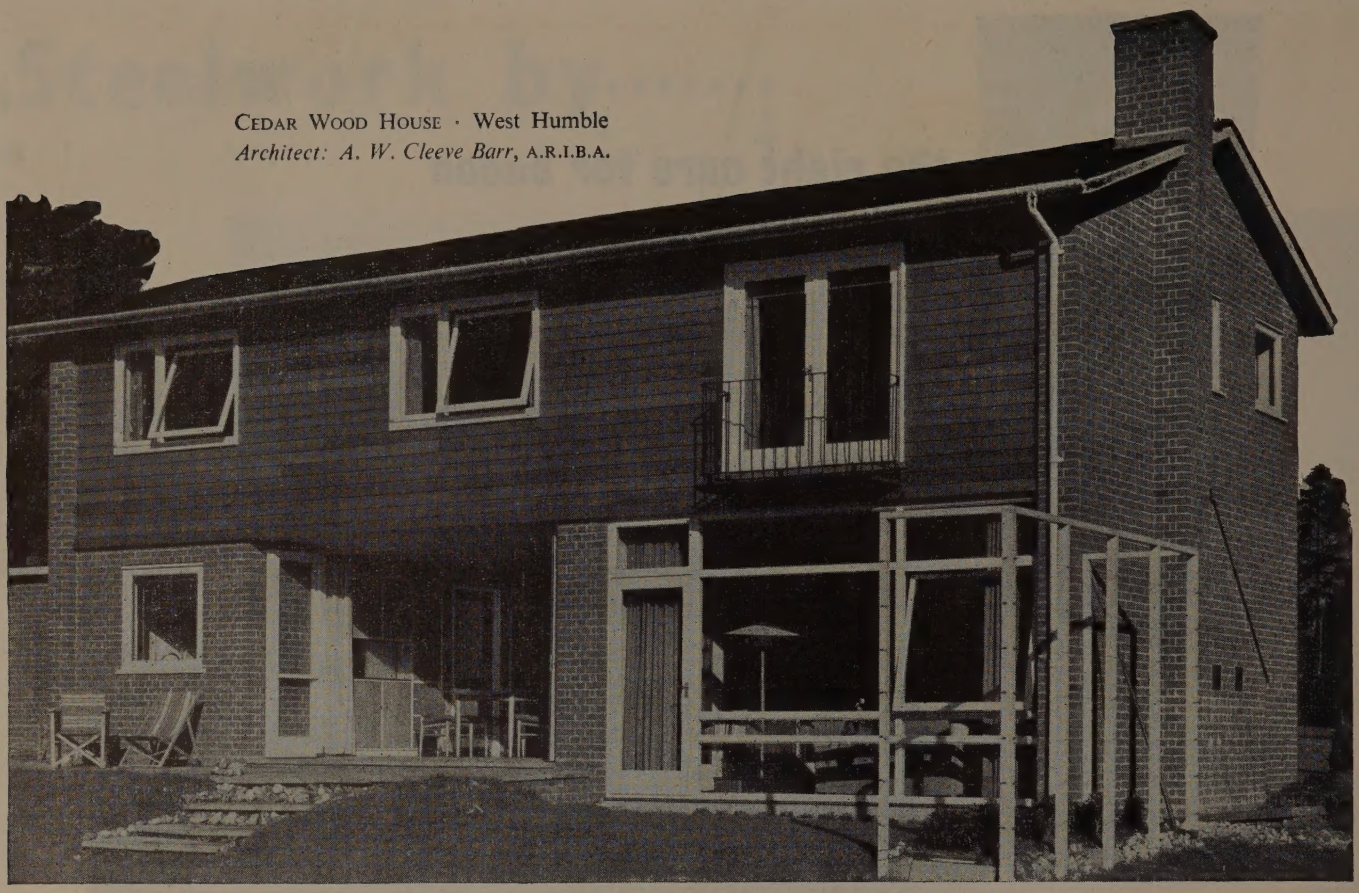
FREE ADVISORY SERVICE

With 35 years' practical experience our technical department can offer constructive assistance on specific concrete problems including the preparation of complete specifications.

Write for full technical information **STUART B. DICKENS LIMITED**

36 Victoria Street, London, S.W.1. Telephone: Abbey 4930 & 6157. Works: Manor Way, Boreham Wood, Herts. Telephone: Elstree 2211

CEDAR WOOD HOUSE · West Humble
Architect: A. W. Cleeve Barr, A.R.I.B.A.

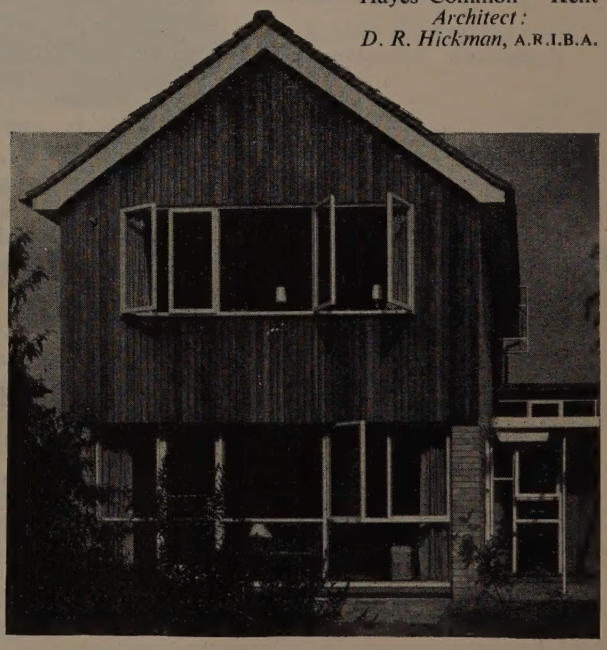


CANADIAN TIMBER

for imaginative design at low cost

Canadian timber when used by an architect can be as pliable and expressive as clay in the hands of a sculptor. No other building material provides such vast opportunities for imaginative design at low cost. It is so wonderfully versatile, a material of great natural beauty, blending happily with other materials and lending itself to a host of structural and decorative uses. It is easy and economical to work. Quickly prefabricated. Amazingly durable. What is more, Canadian timber is warm and friendly to live with. Even with brick facing on wood sheathing and timber frame, the wall structure will have a 'U' value of 0.17 compared with 0.31 for an 11 in. cavity wall.

HEAL HOUSE
Hayes Common · Kent
Architect:
D. R. Hickman, A.R.I.B.A.



SEND FOR 'TRENDS IN TIMBER CONSTRUCTION'
— an 18-page pictorial study of timber's wide range of uses in present day structures of all types. Write for your free copy to :

COMMERCIAL COUNSELLOR (Timber)
Dept. QI, Canada House, Trafalgar Square, London SW1

CANADIAN TIMBER **FROM BRITISH COLUMBIA**

Pacific Coast Hemlock. Douglas Fir. Western Red Cedar. Sitka Spruce.

High quality timber produced by members BRITISH COLUMBIA LUMBER MANUFACTURERS ASSOCIATION

Ad. No. 1

THE NEW BRITISH OXYGEN

SAFFIRE

NOZZLE MIXING CUTTER

The most advanced Cutting Blowpipe available today.

For full details please write to:

BRITISH OXYGEN

British Oxygen Gases Ltd., Bridgewater House, St. James's, London, S.W.1

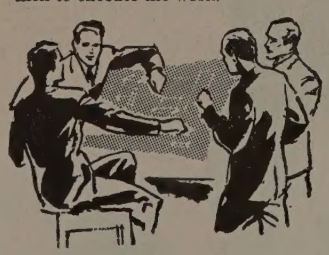
Roofing by

RUBEROID

All the flat and very low-pitched roofs of the buildings at Dounreay are covered with Ruberoid roofing: total area 22,435 sq. yds. (over 4½ acres).

YOUR PARTNERS IN SERVICE

We offer to you, through our Contracts Department, the benefits of many years of experience in matters concerning roofing: expert advice at the planning stage and skilled craftsmen to execute the work.



Gales of 100 m.p.h. sweep savagely across the low, level stretches of our Northern Scottish shores. Heavy Caithness slab tiles are the traditional roofing material for the windswept expanses of Dounreay.

But away went tradition as the great project for the United Kingdom Atomic Energy Authority reached planning stage. For the large roof spans visualised, the amount of support needed for heavy slab tiles would have been formidable in the extreme. The Ruberoid Company Limited was called in.

Specifications were submitted and accepted for Ruberoid Insulated Steel Deck Roofing, pictured above: light, strong, well-insulated against heat loss, quick to erect (dry cover was rapidly made available for other trades who worked speedily in reasonable comfort). The final layer of Ruberoid built-up weatherproofing incorporates Scottish granite chippings to increase solar reflectivity and add local character to the appearance of the roofs.

Protection of the Dounreay buildings by Ruberoid products is not confined to roofs alone. Many thousands of yards of Astos Asbestos Dampcourse incorporated in the walls are keeping the structures free from rising damp. The Ruberoid Company also provided a membrane of bitumen macadam on the raised dais under each Tank Farm.

For technical literature write or telephone—

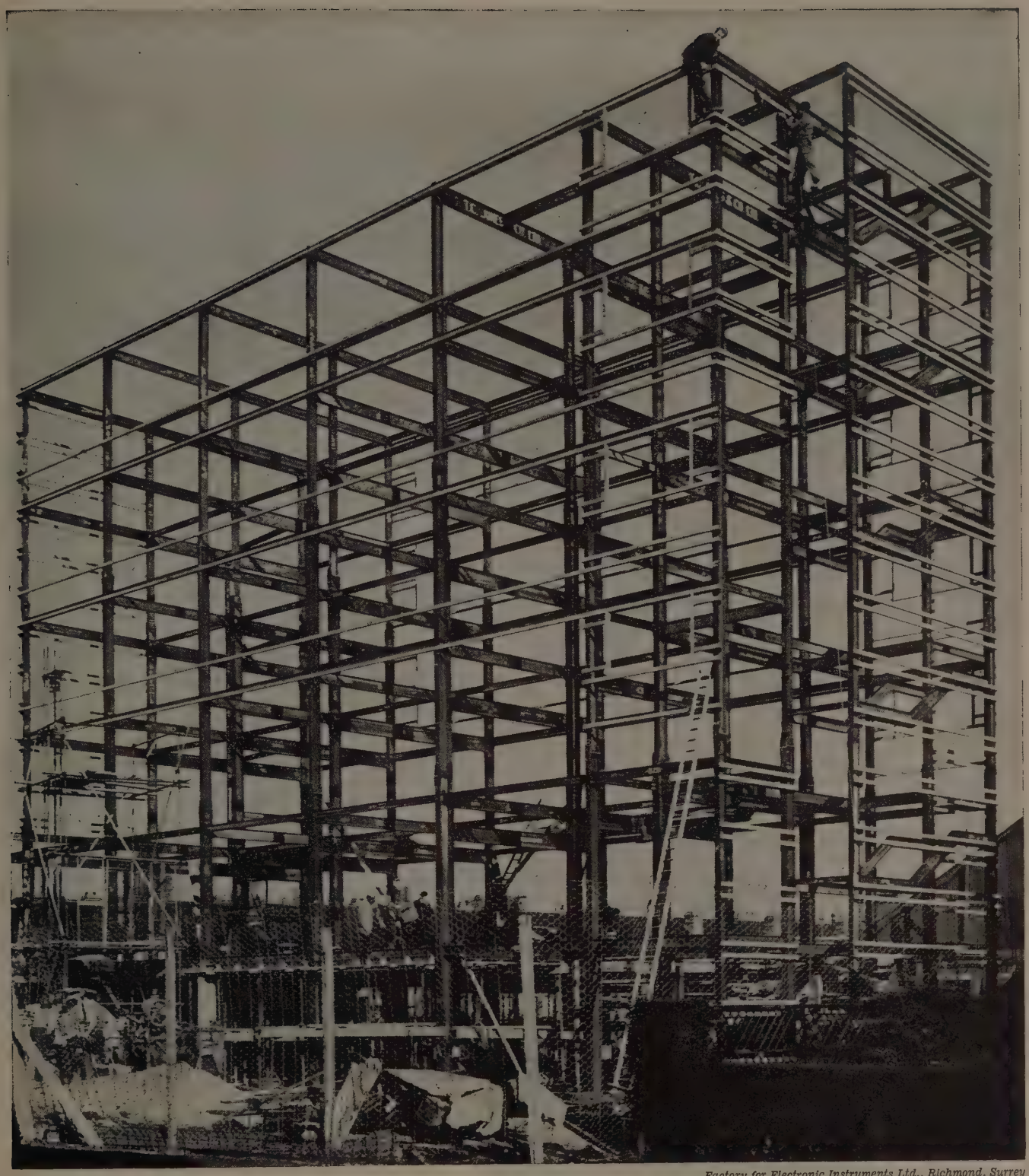
TRADE MARK RUBEROID REGISTERED

THE RUBEROID COMPANY LIMITED

351 COMMONWEALTH HOUSE, 1-19 NEW OXFORD STREET, LONDON, W.C.1. HOLBORN 8797 (10 LINES)

BRANCHES: Belfast, Birmingham, Bristol, Edinburgh, Glasgow, Manchester Newcastle-on-Tyne, Nottingham. C116d

Visit Our Stand No. 234, Row G, BUILDING EXHIBITION, OLYMPIA, Nov. 13th - 27th, 1957



Factory for Electronic Instruments Ltd., Richmond, Surrey

This is a *C.A.S. (Developments) Ltd.* development. Architect: KENNETH ANNS, M.C., F.R.I.B.A.
Consulting Architect: A. B. WATERS, M.B.E., G.M., F.R.I.B.A.
Consulting Engineers: ANDREWS, KENT & STONE. Contractors: C.A.S. (Contractors) Ltd.

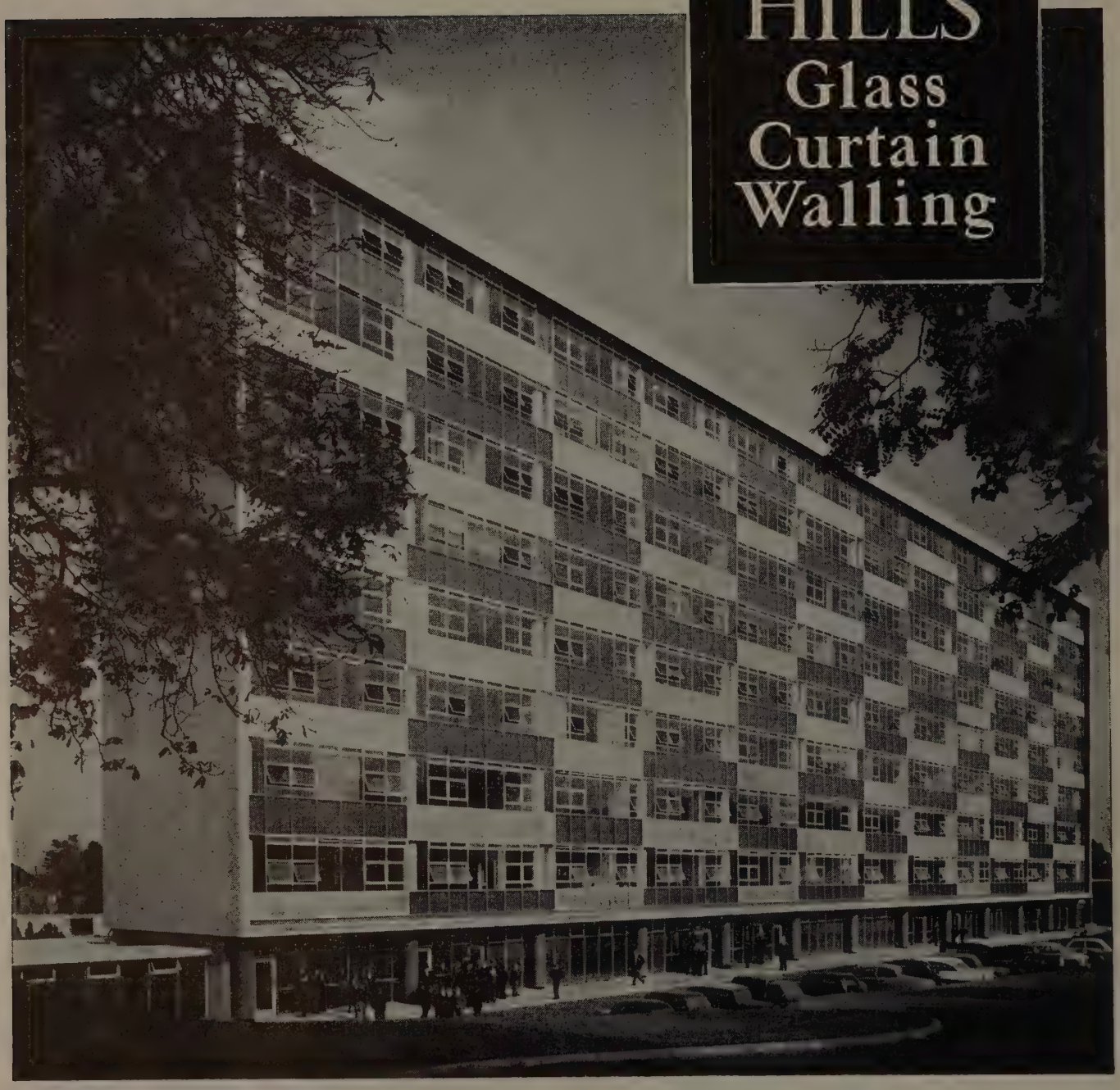
STEELWORK FABRICATED & ERECTED BY

T. C. JONES
AND COMPANY LIMITED

THE 600 GROUP OF COMPANIES

HEAD OFFICE: WOOD LANE, LONDON, W.12 *Telephone:* SHEpherds Bush 2020
SOUTH WALES OFFICE: 2 PIERHEAD CHAMBERS, BUTE STREET, CARDIFF *Telephone:* Cardiff 28786
REINFORCEMENT DEPARTMENT: 17 BUCKINGHAM PALACE GARDENS, LONDON, S.W.1 *Telephone:* SLOane 5271
WORKS: Shepherds Bush, London · Neasden, Middx · Treorchy, Glamorgan

HILLS Glass Curtain Walling



Tulse Hill School. Architect to the London County Council: Dr. J. L. Martin, M.A., Ph.D., F.R.I.B.A.

ILLUSTRATED is one of the many contracts completed in 1956 where Hills Glass Curtain Walling has been used. Developed for buildings designed on co-ordinated modular construction, this most economical permanent cladding can be used with any type of framed buildings of any height as well as Hills Presweld Steel Frame. Over 1,000,000 ft. super of Hills Glass Curtain Walling have now been supplied and erected. Architects and Contractors are invited to write for illustrated literature.

HILLS (WEST BROMWICH) LIMITED

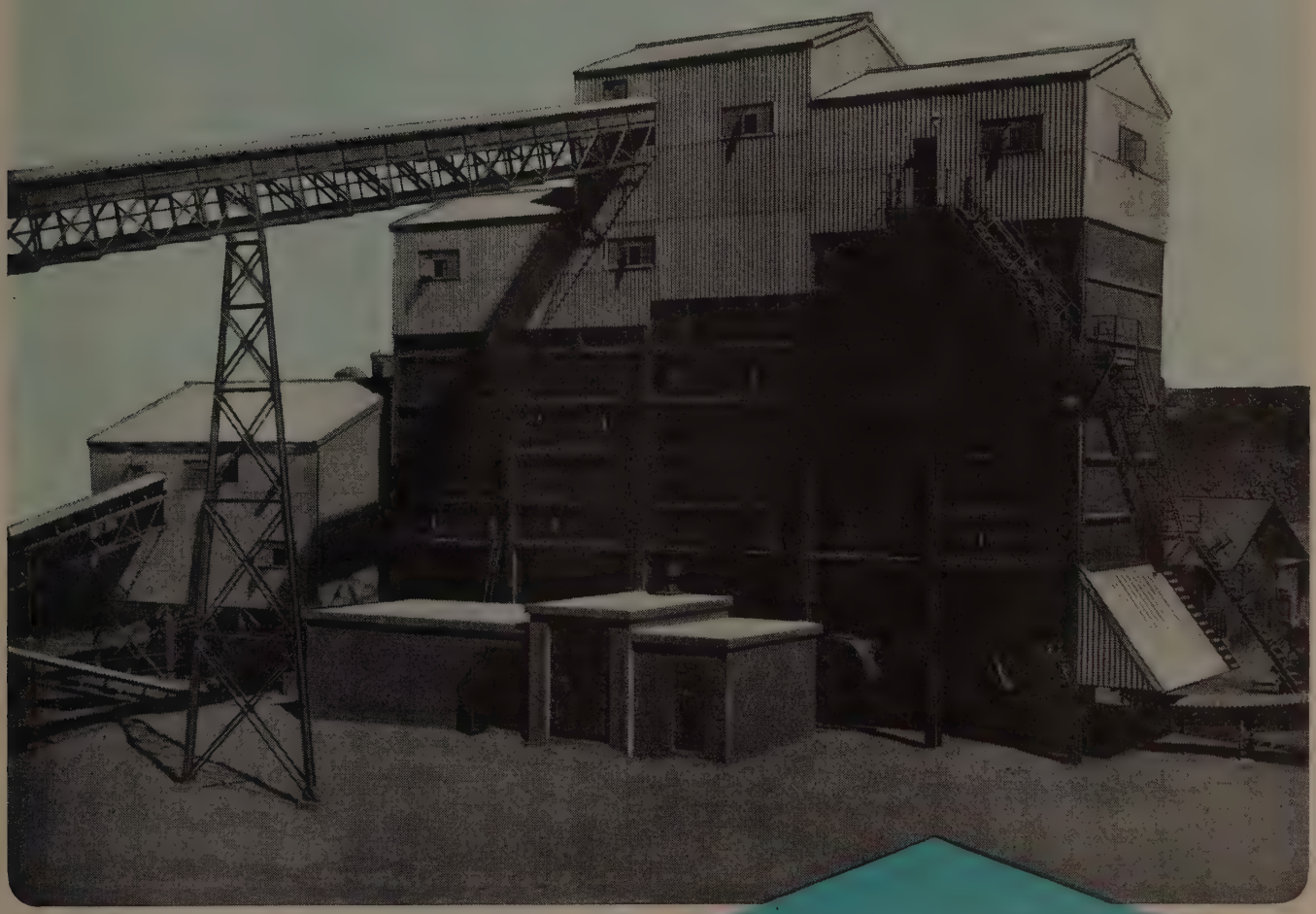
ALBION ROAD, WEST BROMWICH, Staffs.

Tel: West Bromwich 1811 (15 lines)

LONDON: CHAPONE PLACE, DEAN STREET, W.1 Telephone: GERrard 0526/9

Branches at Birmingham (Midland 5175), Manchester (Blackfriars 3382/3), Bristol (24765), Newcastle-on-Tyne (25060), Glasgow (City 5564), Belfast (Dundonald 3526)

STRUCTURAL STEELWORK by SKINNINGROVE



BATCHING and SCREENING UNIT

Part of the new Plant installed at Skinningrove by Messrs. TARMAC LIMITED in May, 1955. This plant was designed and erected by Messrs. STOTHERT & PITT LIMITED, Bath for whom SKINNINGROVE supplied the fabricated steelwork.

SKINNINGROVE IRON Co LTD
P. O. BOX No. 1
SALTBURN, YORKSHIRE

STEEL SECTIONS AND JOISTS and all TYPES OF FABRICATED STEELWORK

Telephone: LOFTUS 212 (5 Lines)

No hidden errors...

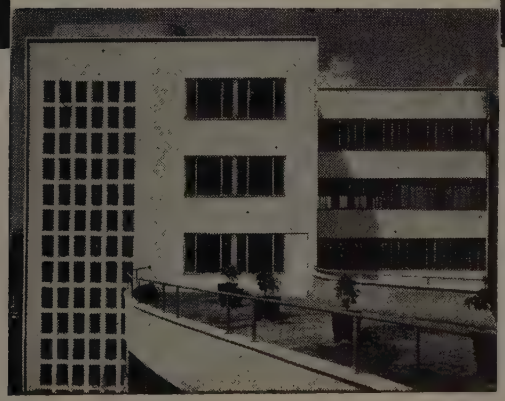
Schoolmasters may sometimes consign their pupils to the nether regions though not usually so literally as this. In construction work of any kind it is always the undiscovered fault which produces unexpected consternation at a moment's notice. That is why it's better to build with steel — steel which has all its connections clearly visible, and into which no hidden errors can creep to destroy its security.

better build it with **BOOTH** Steelwork

JOHN BOOTH & SONS (BOLTON) LTD., HULTON STEELWORKS, BOLTON
Telephone: BOLTON 1195 LONDON: 26 VICTORIA STREET, WESTMINSTER, S.W.1. *Telephone:* ABBey 7162

SAVE MONEY by building in REINFORCED CONCRETE

New Office building for Sir Lindsay Parkinson & Co. Ltd., St. George's Circus, S.E.1., acting as own contractor.
Architects: Moiret & Wood, in liaison with the Company's chief architectural surveyor, Tristan G. Walden, F.R.S.A., F.F.S.(Eng), A.M.S.E.
Structural engineering consultants: Malcolm Glover & Partners.
Reinforced concrete construction throughout:—columns, structural floors, stairs, liftshafts, mullions, external walls (main elevations) faced with polished marble cladding slabs which formed permanent shuttering; flank walls of in situ concrete finished with a 'Cemprover' treatment.



REINFORCED CONCRETE is being used increasingly in Great Britain for offices, factories, warehouses, flats, schools and similar building and industrial projects, as it has proved itself the *cheapest form of construction.*

For the building frame, external cladding, staircases, floors and roof, reinforced concrete offers many advantages—in addition to that of low cost. Modern concrete technology, aided by research—The Blue Circle Group of Companies alone spend about £300,000 each year on research and development—and the availability of the range of Blue Circle Products for structural and decorative concrete, have placed concrete in the forefront of modern constructional materials.

The services of our Technical and Advisory Department are at your disposal

A BLUE CIRCLE CMC PRODUCT

THE CEMENT MARKETING COMPANY LIMITED
PORTLAND HOUSE, TOTHILL STREET, LONDON, S.W.1
G. & T. EARLE LIMITED, HULL
THE SOUTH WALES PORTLAND CEMENT & LIME CO. LTD., PENARTH, GLAM.

STRUCTURAL STEELWORK BY FINDLAY

BRITAIN'S ATOMIC FACTORIES

Capenhurst

Part of the Capenhurst Atomic Plant under construction. (By kind permission of United Kingdom Atomic Energy Authority)

25,000 TONS OF STEELWORK

UNDER DIRECT CONTRACT WITH THE MINISTRY OF WORKS ALEX. FINDLAY & CO. LTD. MOTHERWELL HAVE SUPLIED, DELIVERED AND ERECTED OVER 25,000 TONS OF STEELWORK TO BUILD THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY PLANT AT CAPENHURST WORKS, CHESTER

ALEX. FINDLAY & CO. LTD.

STRUCTURAL ENGINEERS

MOTHERWELL · SCOTLAND

Phone Motherwell 2301 (6 lines)

Member of the Nuclear Power Plant Co. Ltd.

LONDON OFFICE: HIGH HOLBORN HOUSE, 52/54 HIGH HOLBORN W.C.1 TELEPHONE HOLBORN 7330-5083

work in progress

HOWARD FARROW LTD

Members of the British Institute of Management.

Wherever the sign of Howard Farrow appears there is work in progress. The above photograph illustrates form-work in the construction of main drainage for the Torquay Corporation.
Howard Farrow Ltd. are also contractors to the War Department and Air Ministry, and specialise in sewerage works and disposal, concrete structures, roads, bridges, building, estate development and water schemes.

CIVIL ENGINEERING & BUILDING CONTRACTORS

BANK BUILDINGS, RUSSELL PARADE, GOLDERS GREEN RD., LONDON, N.W.11. Telephone SPEedwell 0061/7

. . . this NEW PUBLICATION gives the solution to most foundation problems send for your copy NOW!

FRANKIPILE THE FRANKI COMPRESSED PILE CO. LTD · 39 VICTORIA STREET · LONDON · SW1

THE BUTTERS *Light* MONOTOWER CRANE

1 **The tower lies horizontally with the jib underneath . .**

2 **The tower is hauled up by its own gear, the jib hanging downwards . .**

3 **The jib is pulled outwards before the tower reaches the vertical . .**

4 THE COMPLETED MONOTOWER CRANE

Ready for service

A surprisingly simple and speedy operation

Dismantling is just as easy

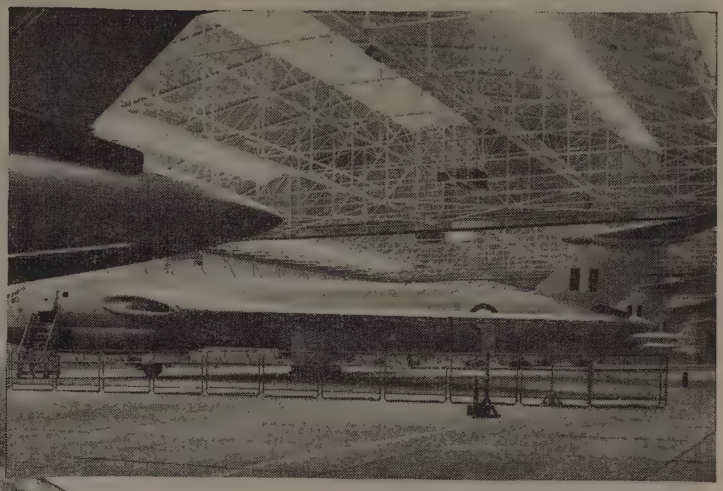
Full details sent on request.

BUTTERS BROS. & CO. LTD.,

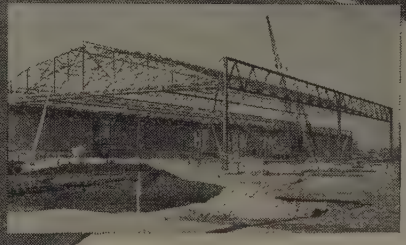
Glasgow, London, Birmingham, Newcastle.

Building the future

New Platers' shops and Assembly shops at the works of Austin Pickersgill, Sunderland.



Maintenance hangar for Messrs. Handley Page, Ltd.



Diesel loco shed at Norwich for British Transport Commission.

In pace with the growing needs of industry Wright Anderson are engaged in the provision of steel buildings to meet every future requirement. Their resources, experience and, above all, their service ensure that the work they do is carried out with close regard to efficiency, time and economy.

WRIGHT ANDERSON & CO. LTD. STRUCTURAL ENGINEERS — DESIGN FABRICATION ERECTION — RELIABILITY

WRIGHT ANDERSON & CO. LTD.

CONSTRUCTIONAL ENGINEERS AND BRIDGE BUILDERS

G.P.O. BOX 2, GATESHEAD, CO. DURHAM

Tel: Gateshead 72246 (3 lines). Grams: "CONSTRUCT Gateshead"
London Office: Regent House, Kingsway, W.C.2. Tel: HOLborn 9811

CONTRACTORS TO H.M. GOVERNMENT, CENTRAL ELECTRICITY AUTHORITY, NATIONAL COAL BOARD, ATOMIC ENERGY AUTHORITY AND CROWN AGENTS FOR OVERSEAS GOVERNMENTS AND ADMINISTRATIONS

P4511

Had his construction kept pace with the times he might be in business today

Tyrannosaurus Rex stood high among the monarchs of the primeval jungle.
Indeed if his height had been supported by a structure of enduring stability he might be with us still.
However this brings us smoothly to Prestressed Precast Concrete—a development as advanced today as Tyrannosaurus R. was behind the times.
C.D.C. Prestressed Precast Concrete Structural Units are manufactured in our factory at Iver, Bucks, by the fully bonded method of stressing or to other methods specified by clients.
Production is controlled in detail at all stages by experienced engineers and trained staff.
The units are manufactured to agreed schedules, stored on our site when required, to ensure delivery to sites by road or rail *when they are scheduled to be received.*
This enables site erection schedules to be maintained, work on site, i.e. shuttering, steel erection, concreting, being reduced to the minimum, thereby reducing waste and delays due to inclement weather.

Order your requirements in Prestressed and Precast Structural Units from Concrete Development Company and reduce building costs and construction time. Our units are made to measure to your design or those of our Design Department. In either case our engineers will be glad to collaborate with you.

CDC

CONCRETE DEVELOPMENT COMPANY LIMITED. OFFICE AND WORKS: IVER, BUCKS. TELEPHONE: IVER 1131

For **SEA DEFENCE WORKS**

LARSSEN STEEL SHEET PILING

ROLLED EXCLUSIVELY IN THE UNITED KINGDOM BY

South Durham

Photograph by courtesy of the Central Electricity Authority

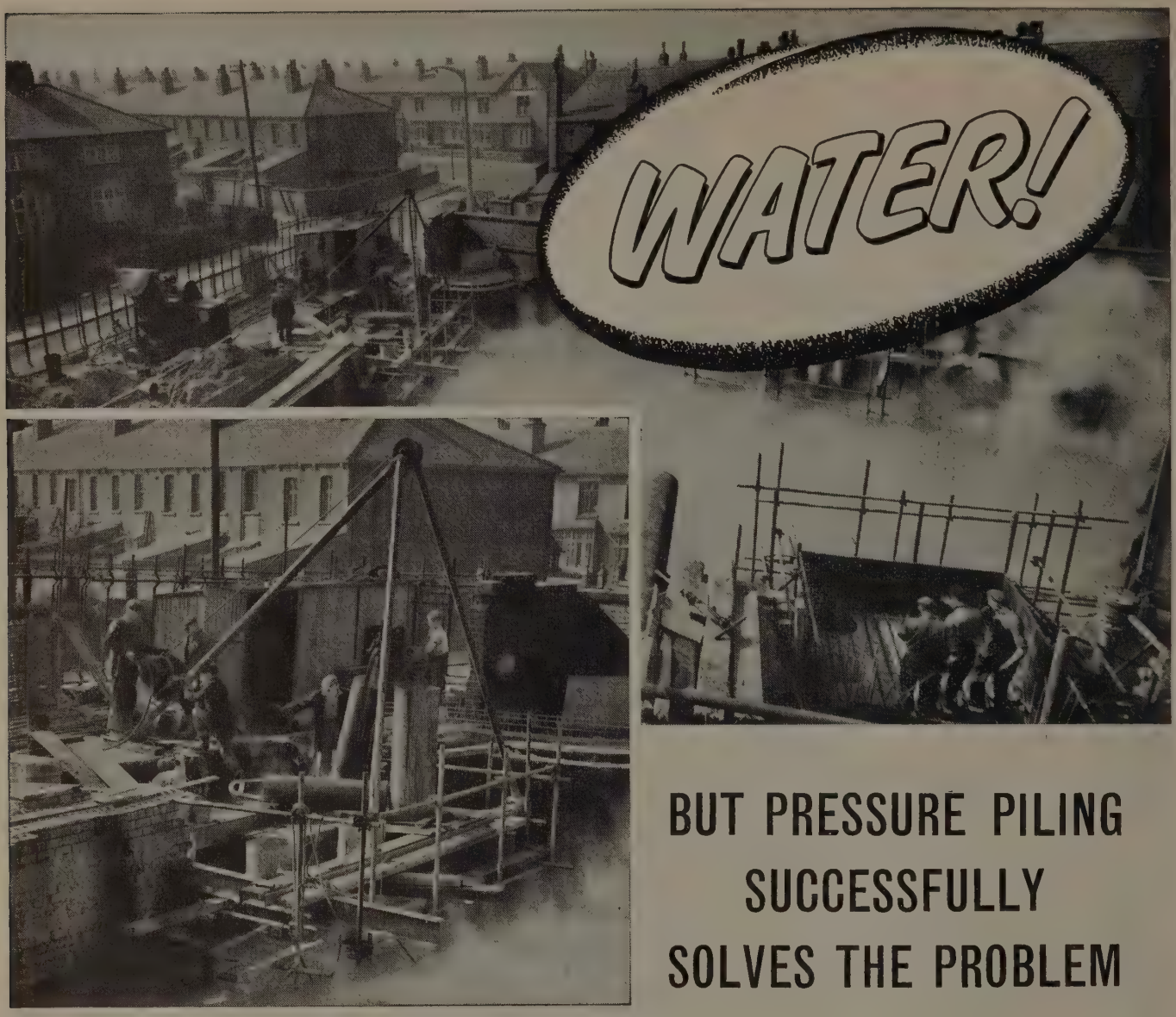
Strength and durability, ease in driving, water-tightness and resistance to corrosion combine to make Larssen Steel Sheet Piling the outstanding material for use in the construction of sea defences. Available in a range of nine sections together with all standard types of corner, junction and box piles.

Technical advice and assistance from the Company's expert design staff are available on request

SOUTH DURHAM STEEL AND IRON COMPANY LIMITED

CARGO FLEET IRON WORKS, MIDDLESBROUGH, YORKS.

Telephone: Middlesbrough 2631 (14 lines).



BUT PRESSURE PILING SUCCESSFULLY SOLVES THE PROBLEM

Based on the sound principle of casting reinforced concrete piles *in situ*, the Pressure Piling System is applied with such a wealth of practical experience that sinking piles in waterlogged strata, at the waterside, or *in* the water, tidal or static has become a routine operation. Over a million feet of Pressure Piles have now been installed under all sorts of conditions—and when you consult Pressure Piling this experience is freely at your disposal.

THE
PRESSURE PILING COMPANY (PARENT) LTD
637 OLD KENT ROAD, LONDON, S.E.15
Tel: New Cross 0347/8/9

Enquiries for the North of England, Scotland, Northern Ireland and Eire should be addressed to:—

THE
PRESSURE PILING COMPANY (Northern) LTD
6 WINCKLEY SQUARE, PRESTON, LANCS.
Tel: Preston 5221

The Original and LARGEST Bored Piling Specialists in the World

THIS BOOK WILL INTEREST ENGINEERS

Architects and Engineers are invited to write or phone us for a copy of "The Pressure Piling System." This informative booklet gives you technical data on piled foundations and underpinning for rapid vibrationless construction and repairs. It is free and post free.

THE PRESSURE PILING COMPANIES

Current contracts include:—
British Celanese Ltd.,
Imperial Chemical Industries Ltd.,
Brymbo Steel Works Ltd.,
Stewarts and Lloyds Ltd.,
Steel Company of Wales Ltd.

Makers since 1790 *of:—*
Railway and other bridges;
Constructional steelwork;
Unit bridging; Iron paving;
Wrought Iron bars;
Overhead cranes;
Railway wagons and Mine cars;
Meehanite castings;
Mining and Sheet Metal machinery;
Sewage ejectors and pumps;
Wool washing machinery;
Aglite lightweight aggregate;
High quality bricks.

BUT 9296

ORE and ADMIRATION

Steelmen, however old, never fail to feel—no matter how many times they've seen it—the awe and excitement of a furnace in full blast. From apprentice to Chief Smelter, that amazingly skilled aristocrat of the foundries, the thrill remains as sharp as ever with the sweat and heat and glory of it all.

It is well known by steelmen that high purity oxygen in blast, Bessemer or open hearth makes for considerably greater heat much more cheaply. This oxygen is best produced by Butterley on-site Tonnage Oxygenerators and allows a still wider range of quality steels.

While being compact and efficient, these plants produce a continuous supply of oxygen and/or nitrogen at any desired purity and pressure at any quantity needed where there's work with oxygen afoot.

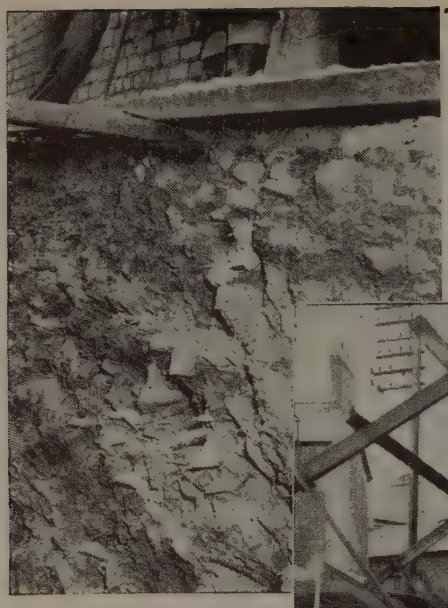
Sole production and sales rights have been acquired by Butterley from America for U.K., British Commonwealth and certain European countries. If you can use oxygen, consult Butterley Oxygen Division.

If you can use Oxygen, consult

BUTTERLEY

OXYGEN DIVISION

Oxygen Division, The Butterley Company Limited, 9 Upper Belgrave St., London, S.W.1. Tel: SLOane 8172/3



SAFE EXCAVATION WITHOUT TIMBERING *Thanks to* CEMENTATION

Aberystwyth Borough Council wished to excavate a sewer trench through a very narrow street and within a few feet of houses on each side.

Excavation by normal methods was impracticable without extreme hazard to stability of adjacent structures. Cementation enabled the work to be completed safely, permitting, as can be seen from the photographs, vertical trenching without support.

The Cementation Co. Ltd., has the experience, the facilities and the resources to carry out foundation treatment on almost any scale, in any part of the world.

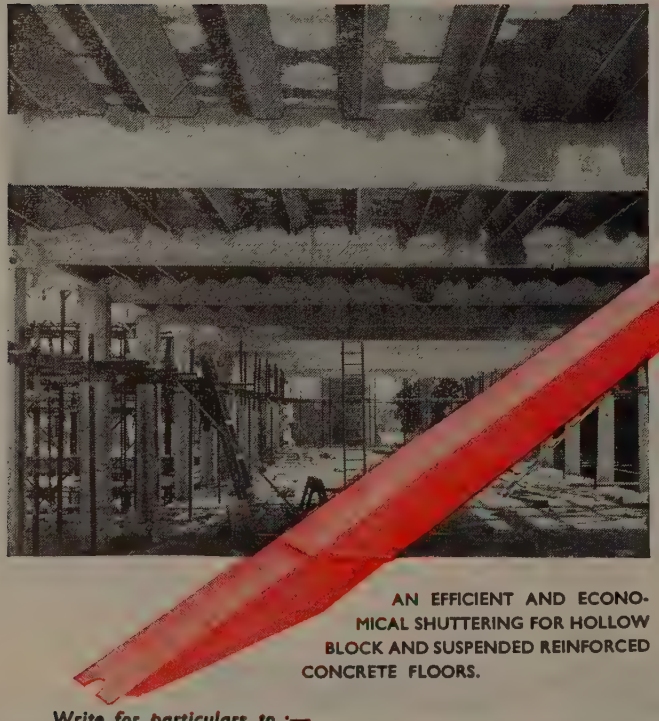
The CEMENTATION COMPANY LIMITED

Head Office :
20 ALBERT EMBANKMENT, LONDON, S.E.11
Tel. : RELiance 7654

Office & Works:
BENTLEY WORKS, DONCASTER
Tel. : 54175 and 54136

TRIANCO

TELESCOPIC CENTERS



AN EFFICIENT AND ECONOMICAL SHUTTERING FOR HOLLOW BLOCK AND SUSPENDED REINFORCED CONCRETE FLOORS.

THE ORIGINAL TELESCOPIC SHUTTERING
Used by LEADING CONTRACTORS

Spans from 2' 10½" up to 16' 6" at competitive prices

Speedy to erect and dismantle

Simple to handle — no skilled labour required

Safe to use — combined with light weight

Saving of Timber

The lightness in weight of these Centers in no way impairs their strength owing to the triangular design, which feature provides ample strength and at the same time facilitates handling on site.

Write for particulars to :—

TRIANCO LIMITED · IMBER COURT · EAST MOLESEY · SURREY
Telephone: EMBerbrook 3300 **Telegrams: TRIANCO, EAST MOLESEY**

New "BROOMWADE" MV 60

Super torque drill

★ DRILLS & REAMS UP TO 1¼ in. Diam.

★ COMPACT

★ IDEAL FOR TAPER REAMING

★ SILENT — VIBRATIONLESS

★ PERFECTLY BALANCED

★ WEIGHS 26 lbs.

The "BROOMWADE" MV 60 drill is supplied with Feed Screw or Grip Handle. Ask for more details or, better still, a DEMONSTRATION

Visit Stand 309 R and 316 Q
BUILDING EXHIBITION
National Hall Olympia
13th-27th November, 1957

"BROOMWADE"

AIR COMPRESSORS AND PNEUMATIC TOOLS

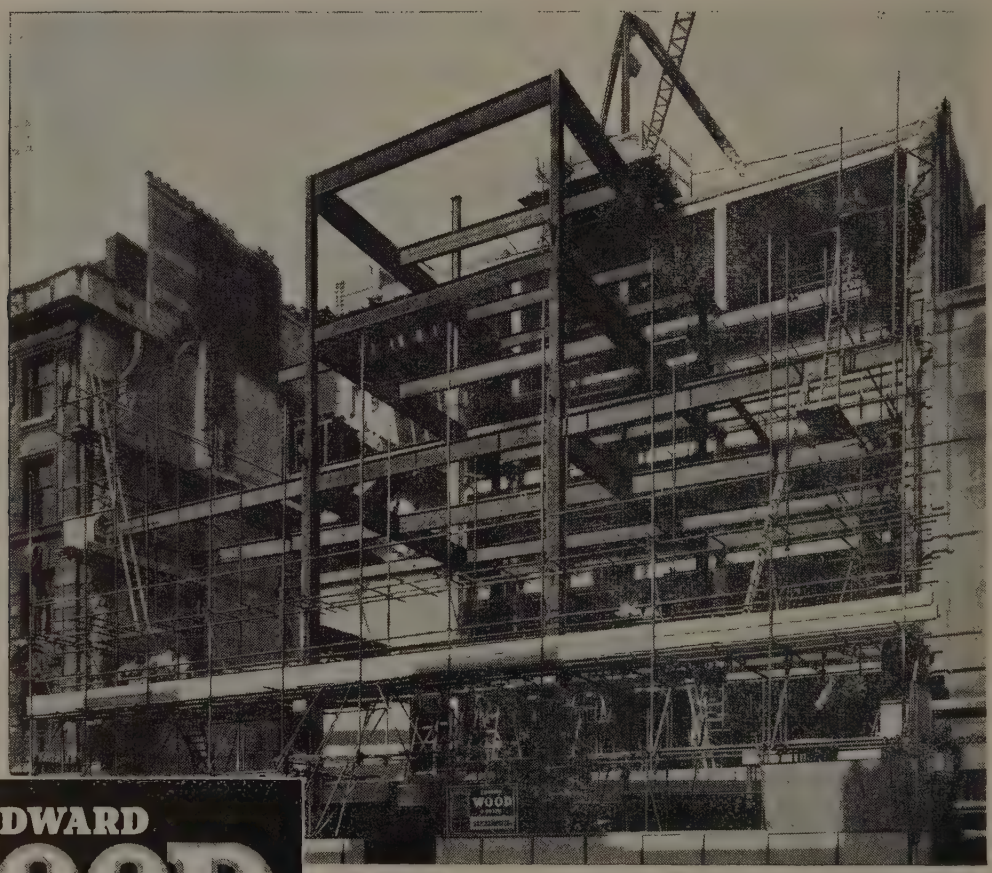
Your Best Investment

BROOM & WADE LTD., P.O. BOX No. 7, HIGH WYCOMBE, ENGLAND

Telephone : High Wycombe 1630 (10 lines). *Telegrams : "Broom," High Wycombe, Telex.*

507 SAS

Landmarks of the Future



Architect: G. S. Hay, A.R.I.B.A.
Architects Dept.: C.W.S. Limited
Manchester.

EDWARD WOOD & CO LTD

CONSTRUCTIONAL ENGINEERS

Deansgate, Manchester, is the site of this striking new building at present under construction for Co-operative Emporium Ltd. Bringing a new department store into the heart of Manchester's Shopping area, this will be another landmark with Steelwork by Edward Wood & Co. Limited.

Registered Office and Works:

OCEAN IRONWORKS · TRAFFORD PARK · MANCHESTER 17

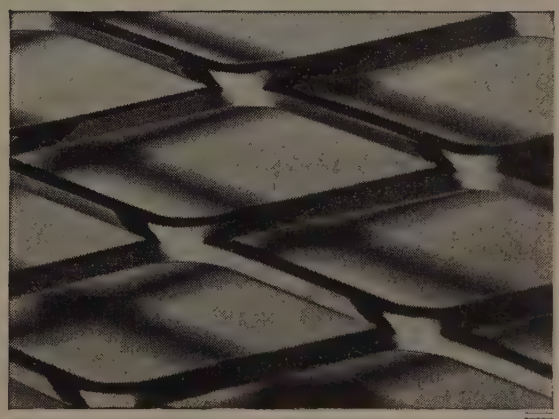
London Office: 68 *Victoria Street, S.W.*1 *Telephone: VICtoria* 1331/2

Technical Offices at Birmingham and Nottingham

dm WD 63

50 years ago this concrete bridge was reinforced with

EXPANDED METAL



...today's verdict—

EXPAMET can take it!

One of the earliest examples ever constructed in this country of an arched concrete bridge supporting a roadway, was Thorverton Bridge, Devon.
In those days when the finer techniques of reinforced concrete were being learned, the pioneer spirit of Expanded Metal engineers accepted the challenge to design the reinforcement for the bridge. It has withstood the stress of 50 years and still carries the enormously increased load of modern traffic. During the war it was used by heavy armoured divisions.

The Expanded Metal Company Ltd., has long experience in the design and supply of reinforcements for all classes of work.
Modern developments and techniques are handled by its

REINFORCED CONCRETE DESIGN GROUP

Chief Design Office: Burwood House, Caxton Street, London, S.W.1. ABBey 7766. Other Group Centres are at: P.O. Box 14, Stranton Works, West Hartlepool. Hartlepools 5531. 118 Portland Street, Manchester. Central 9855. 182-185 Melchett Road South, Kings Norton, Birmingham. Kings Norton 4241

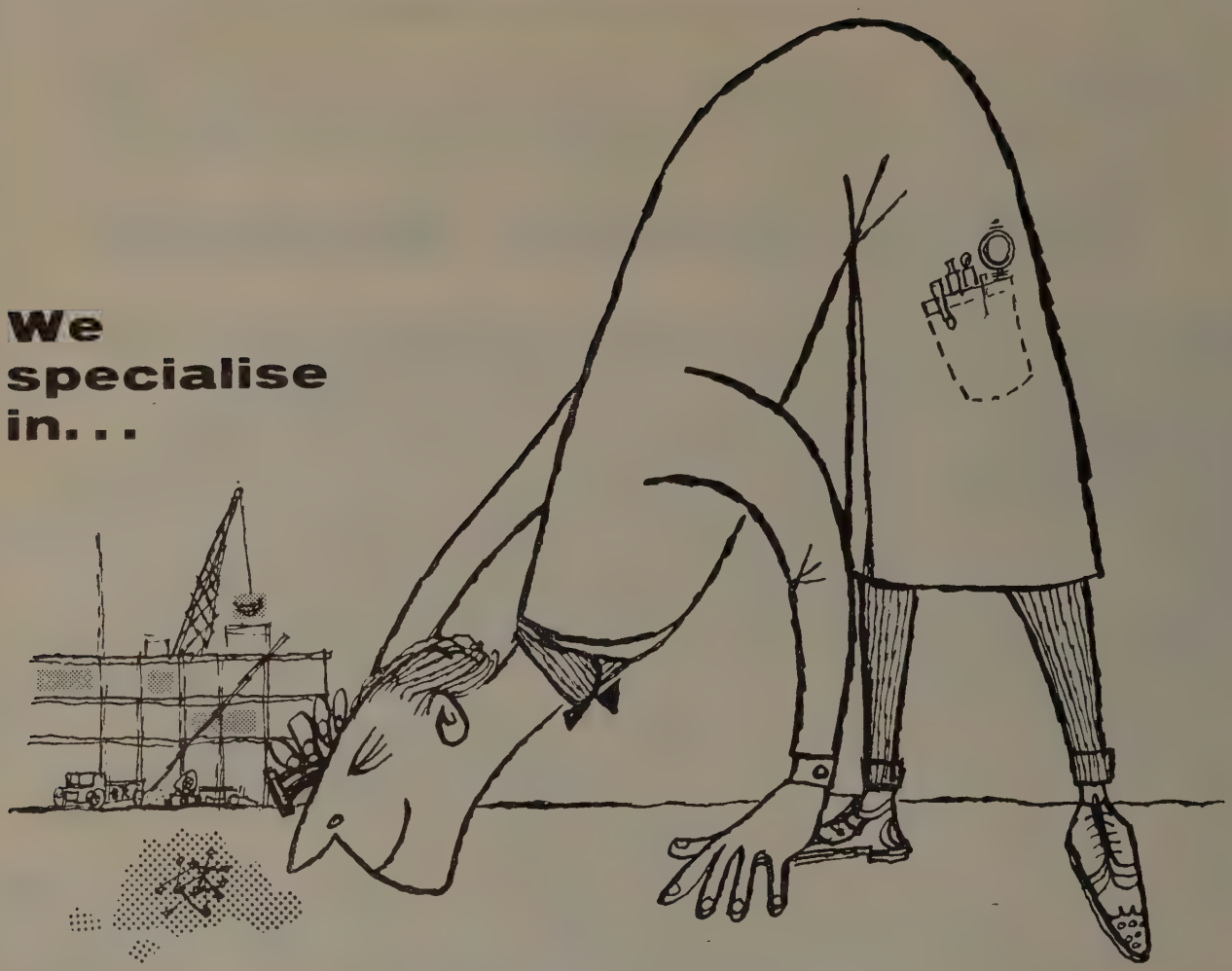
See our Stand No. 84E at the Building Exhibition, Olympia..... November 13th - November 27th.

Expamet

The Expanded Metal Company

Burwood House, Caxton Street, London, S.W.1

ALSO AT: ABERDEEN · BELFAST · BIRMINGHAM · CARDIFF · DUBLIN · EXETER · GLASGOW · LEEDS · MANCHESTER · PETERBOROUGH · WEST HARTLEPOOL



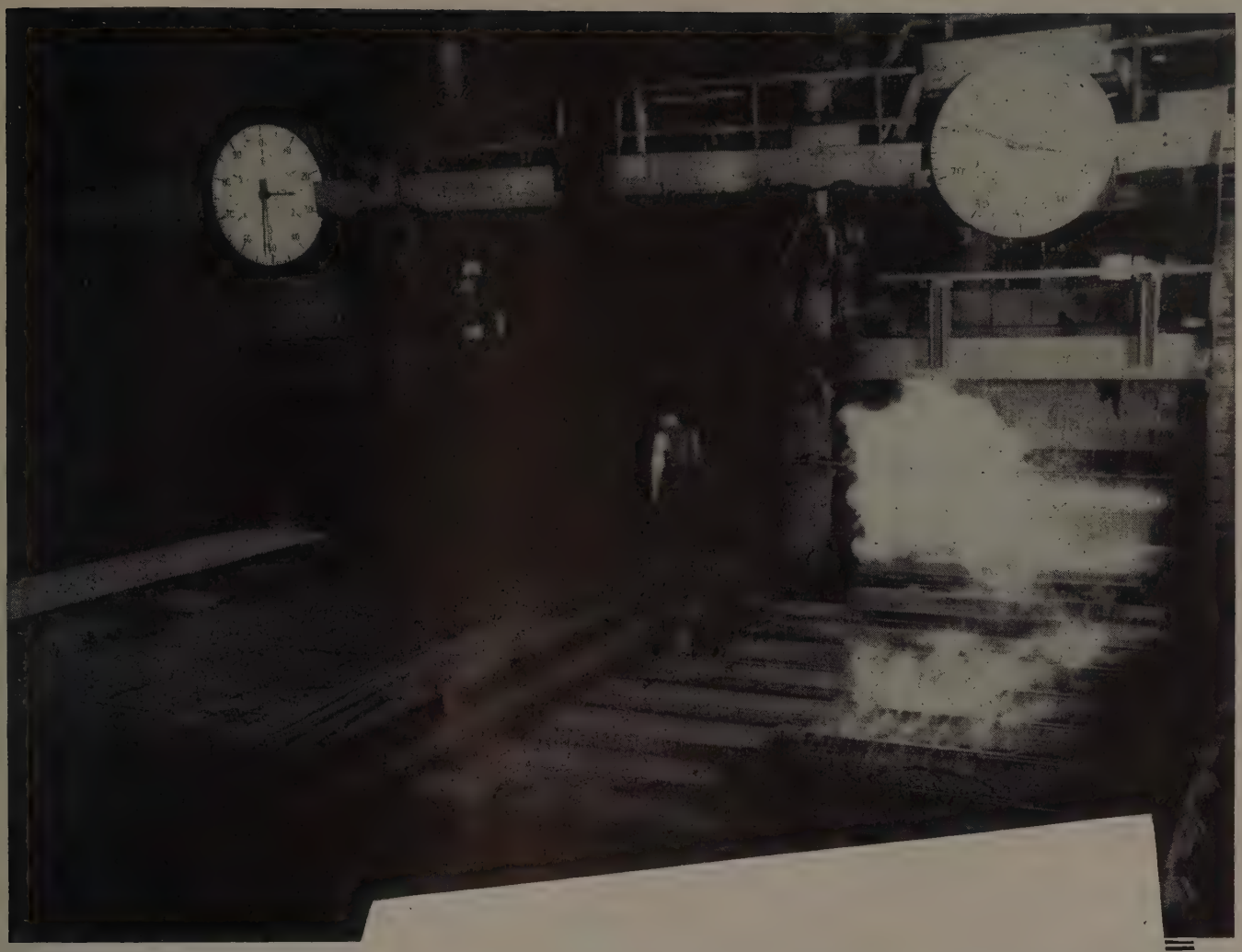
down-to-earth problems!

When choosing a building site, one vital aspect must always be investigated—the characteristics and strength of the subsoil. The Douglas Organization, with its wide experience in all fields of civil engineering construction and building, has laboratory and field equipment to test and design any type of foundation, check earth movements and the stability of slopes and cuttings, and overcome ground water and soft clay, to mention only a few typical problems. We are also pleased to interpret results provided from other sources—so whatever your building or foundation problems, dial for Douglas!

DOUGLAS

SOIL MECHANICS & FOUNDATION
ENGINEERING DEPARTMENT

ROBERT M. DOUGLAS (CONTRACTORS) LTD., 395 GEORGE ROAD, ERDINGTON, BIRMINGHAM 23.
Tel.: BIRCHFIELD 5261 (15 lines) *Telegrams: Aremdee, Birmingham*
ALSO AT LONDON . SWANSEA . LIVERPOOL.



APPLEBY PLATES

for

STRUCTURAL STEELWORK

THE UNITED STEEL COMPANIES LTD

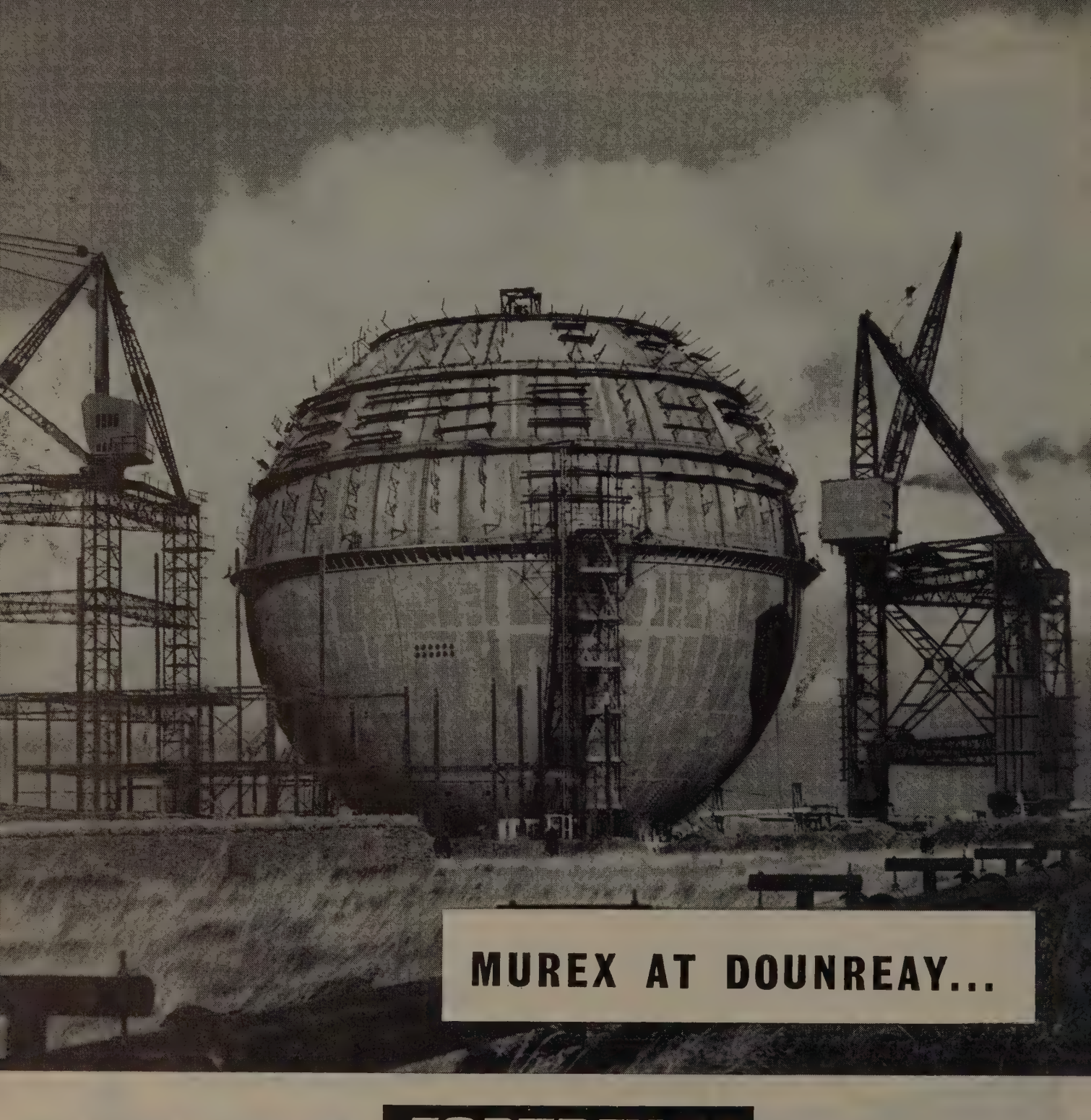
APPLEBY - FRODINGHAM STEEL COMPANY

SCUNTHORPE LINCOLNSHIRE

A Branch of The United Steel Companies Limited

Telephone: Scunthorpe 3411 (12 lines) *Telegrams: 'Appfrod' Scunthorpe*

AF146



60 MILES OF FORTREX 35 ELECTRODE

Over 300,000 ft. of Murex Fortrex 35 Electrodes were used for welding the above sphere at the Dounreay Atomic Energy Plant. These electrodes were exclusively used for all the manual arc welding on this unique and massive sphere which is 135 ft. in diameter and is made up from nearly 300 plates. The sphere has been built by the Motherwell Bridge and Engineering Co, Ltd., Motherwell, to the most exacting requirements of the U.K. Atomic Energy Authority. For such applications only the best electrodes can be used. Murex electrodes are at your service.

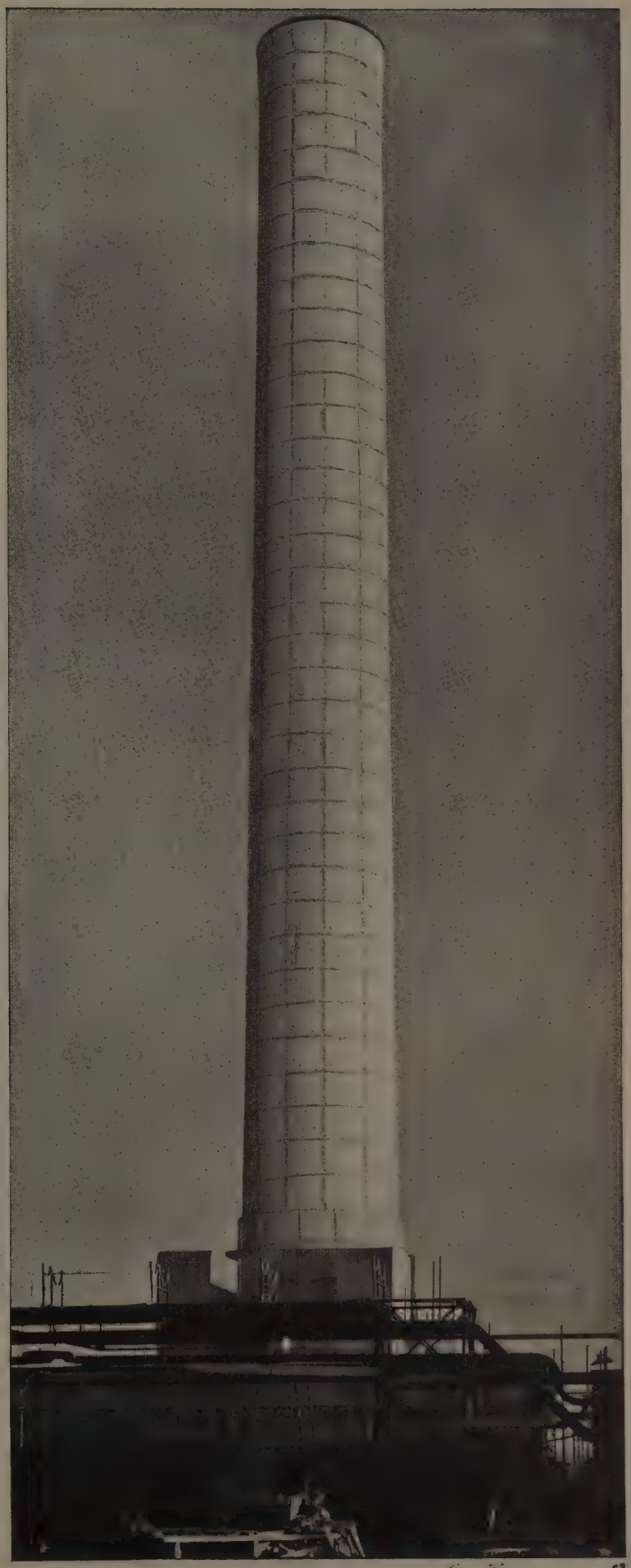
Other contractors at Dounreay using Murex electrodes include Alex Findlay Ltd., Matthew Hall & Co., Ltd., Head Wrightson & Co. Ltd., John Thompson Ltd., Thos. W. Ward Ltd., and Whatlings Ltd.

MUREX ELECTRIC ARC WELDING EQUIPMENT & ELECTRODES

MUREX WELDING PROCESSES LTD., Waltham Cross, Herts. Tel.: Waltham Cross 363

E 26

TILEMAN AND COMPANY LTD



Specialists in design and construction of reinforced concrete structures for nuclear and other power stations

Especialistas en el diseño y construcción de estructuras de hormigón armado para centrales de energía nuclear y otras centrales de energía.

ROMNEY HOUSE, TUFTON STREET, LONDON, S.W.1. Telephone: ABBey 1551

TIL 9060

THE

ONLY

STANDARD

PRECAST

PRESTRESSED

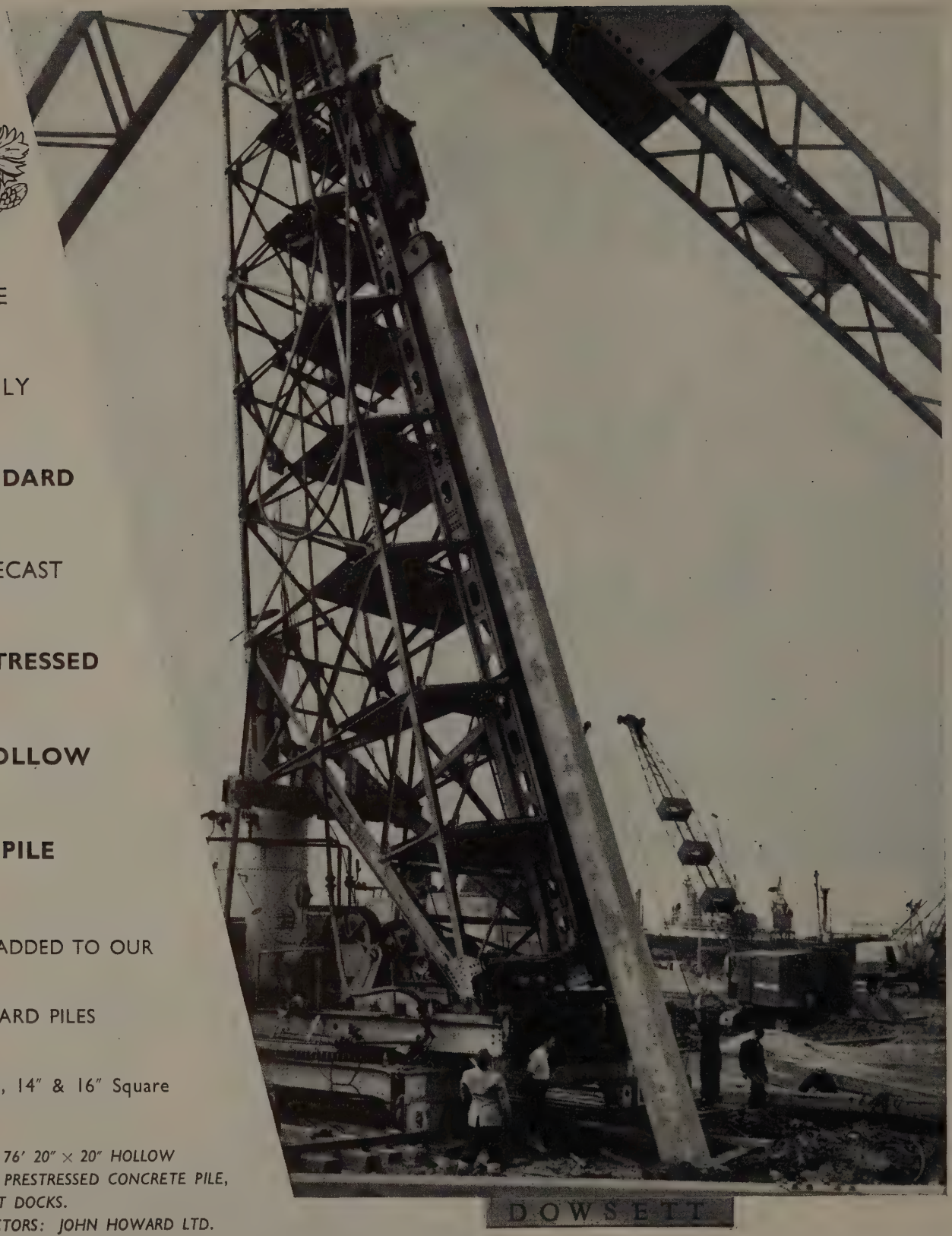
HOLLOW

PILE

NOW ADDED TO OUR

STANDARD PILES

10", 12", 14" & 16" Square



A 76' 20" × 20" HOLLOW PRECAST PRESTRESSED CONCRETE PILE, NEWPORT DOCKS.
CONTRACTORS: JOHN HOWARD LTD.

DOW-MAC (PRODUCTS) LTD

PRESTRESSED CONCRETE

TALLINGTON
STAMFORD, LINCS.
Telephone: Market Deeping 501

LOCAL REPRESENTATIVES:

LONDON	MAYFAIR 8511
NORTH	SUNDERLAND 68498
N. IRELAND	BELFAST 24501

WARRENPOINT
COUNTY DOWN
Telephone: Warrenpoint 2265

VOL. XXXV. No. 11 NOVEMBER, 1957

THE STRUCTURAL ENGINEER

THE JOURNAL OF THE INSTITUTION OF STRUCTURAL ENGINEERS

Founded 1908. *Incorporated by Royal Charter* 1934.

11 UPPER BELGRAVE STREET, LONDON, S.W.1. Sloane 7128/9.

President:
Professor Sir ALFRED PUGSLEY, O.B.E., D.Sc.(Eng.), F.R.S., M.I.Struct.E., M.I.C.E., F.R.Ae.S.

Secretary of the Institution:
Major R. F. Maitland, O.B.E., M.I.Struct.E., M.Soc.C.E. (France).

Assistant Secretary:
Herbert R. H. Gray, A.C.I.S.

CONTENTS

PAGE

PRESIDENTIAL ADDRESS: THE WAY OF RESEARCH 403
By Professor Sir Alfred Pugsley O.B.E., D.Sc.(Eng.), F.R.S., M.I.Struct.E., M.I.C.E., F.R.Ae.S.
The Structural Engineer, November, 1957

STRUCTURAL FEATURES OF THE NEW BINNS STORE IN MIDDLESBROUGH 408
By F. R. Bullen, B.Sc., M.I.Struct.E., M.I.C.E.
The Structural Engineer, November, 1957

THE RELATIONSHIP OF THE ARCHITECT AND THE STRUCTURAL ENGINEER 420
By L. A. Chackett, F.R.I.B.A., F.R.I.C.S.
The Structural Engineer, November, 1957

UNIVERSAL BEAMS AND THEIR APPLICATION 425
By S. Barlow, M.I.Struct.E. and G. Foster, A.M.I.Mech.E.
The Structural Engineer, November, 1957

BOOK REVIEWS 419

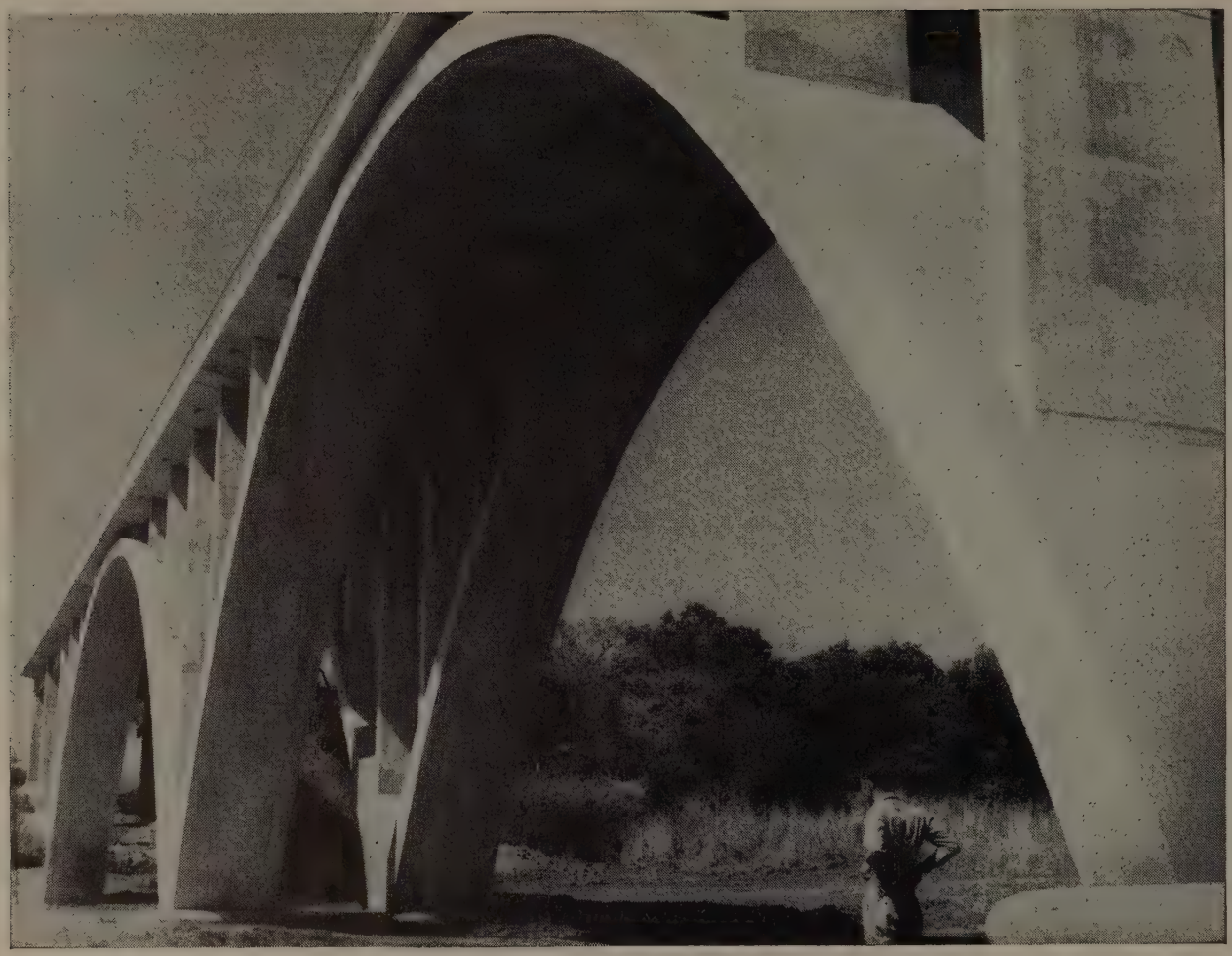
INSTITUTION NOTICES AND PROCEEDINGS 441

All Editorial communications should be addressed to The Editor, The Structural Engineer, 11, Upper Belgrave Street, S.W.1. All MSS. should be typewritten and algebraic signs and formulæ be indicated distinctly.

The Institution of Structural Engineers, whilst being at all times desirous of receiving communications from members and others, does not accept any responsibility for the opinions expressed by any individual Authors or Speakers.

Annual Subscription Rate to the Journal 54s. 0d. post free.

Printed and Published for the Institution by JOHN MORRIS PUBLICITY LTD., Publicity House, 41 Streatham Hill, London, S.W.2, to whom all communications regarding advertisements should be addressed.



BRIDGE CONSTRUCTION

Reinforced concrete bridges in Portuguese East Africa, designed by the Public Works Department. Above, a completed bridge over the Revue River and below, a three-arch span bridge under construction over the Messica River.

LAING

Building and Civil Engineering Contractors

JOHN LAING AND SON LIMITED · GREAT BRITAIN · CANADA · UNION OF SOUTH AFRICA · RHODESIA

PRESIDENTIAL ADDRESS

By Professor Sir Alfred Pugsley, O.B.E., D.Sc.(Eng.), F.R.S., M.I.Struct.E., M.I.C.E., F.R.Ae.S.

THE WAY OF RESEARCH

Address given before the Institution of Structural Engineers at 11, Upper Belgrave Street, London, S.W.1, on Thursday, 3rd October, 1957.

I MUST first thank all members of the Institution most sincerely for the honour they have conferred on me by electing me as President for this session. Conscious of my many shortcomings but fortified by a foreknowledge of the generous support to come from both members and staff, I can only assure you of my best endeavours.

One of my shortcomings is that I stand among you as an academic among professionals. It therefore does not surprise me that the last occasion on which a university professor was called upon to be our President was over ten years ago. What does surprise me, indeed, is to realise that this interval is much less than that apparently deemed fit by older and larger kindred Institutions in this country.

My immediate predecessor in kind, Professor Collins, with wider and perhaps more human experience than my own, was able to survey the growth of the Institution and comment wisely upon the education and training of its younger members. I am in no position to discuss such matters with any assurance. Though I have been a member of the Institution for over thirty years, I have always lived away from its main centre of activity and so taken no prolonged part in its development. As to education for our profession, I have been in university life for only twelve years and must confess that I still do not adequately understand how the process of learning works. Moreover, most of us have heard too much about education in recent years anyway.

In these circumstances, I have tried, as other Presidents before me, to look back over one's work with a view to discovering what can be distilled from it that is likely to be of general interest. Now I have been concerned almost all my life with some form or other of research and development work ; it has therefore occurred to me that, since none of my predecessors have ever concentrated specially upon the place of research in our profession, I should attempt to do so. Unfortunately, I am no Nevil Shute to weave stories of back-room boy activities in the manner of " No Highway," but the fact that I knew him before the war and the more important fact that you are a scientific audience encourage me to try to discuss structural research in my own way.

Professor Pippard, when called upon to give the Unwin Memorial Lecture to the Institution of Civil Engineers in 1949, chose to discuss engineering research in the universities. In doing so, he selected as his prime example the research work of Karl Pearson, L. W. Atcherley, Unwin, Sir Benjamin Baker and others on the design problems of the gravity dam. This work, and the debates it engendered in the early part of this century among the then giants of our profession, culminated in a series of papers and discussions published in the Proceedings of the Institution of Civil Engineers in 1908, the year of our foundation. Towards the end of his lecture Professor Pippard relates " During the preparation of this lecture I have been told by a professor in another university that, when he was young and thinking of entering the profession, he bought for a few shillings some odd volumes of the Minutes of Proceedings of the Institution. Among them was that containing the papers by Wilson and Gore, Ottley and Brightmore, and E. P. Hill, to which reference has been made. Pearson, Unwin and others could have little idea of the effect that their work and arguments would have upon young men of their own and subsequent generations." Reading those dusty volumes bought from a little second-hand bookshop, I was a schoolboy listening to the great masters of their age and privileged to see, in their able hands, something of the value of theory and experiment, and the relation of both to practice ; in short to glimpse the way research worked. This is the theme of my address.

In the Design Office.

Every young engineer engaged in design is sure, at some time or another, to realise some of the limitations of the routine procedure he is using. Commonly, he will not have time to pursue the matter or, if he does, he may well find improvement of the existing method of treatment beyond him. But sometimes he may achieve a step forward in some part of the process, even though he may only be treading ground that, unbeknown to him, has been trodden before ; or he may do this, only to find that his modified process, when applied to a given structure and using given working stresses, produces a less economical structure than does the accepted routine process and so is rejected by his seniors.

Anyone who has gone through this stage in his youth has indeed glimpsed and essayed a step in research, even though he has only done so to feel himself snubbed and thereafter, for self-protection, has returned to the primrose path of the code of practice. One of the kindlier functions of an Institution like ours is to see that youthful attempts of this sort, right or wrong, can be freely expressed and discussed. If ever in any doubt of this myself, I have only to look back to the Institution records of 1927 to see a youthful effort of my own in this kind, and realise once again, much more than I did at the time, the generous and helpful discussion provided then by such men as Ewart S. Andrews, J. Mitchell Moncrieff and Professor J. Husband, all past Presidents and the last happily still with us.

But it is not only in youth that we see the limitations of our routine methods of design, though sometimes in later life we return again and again to struggle with the fundamental problems we first glimpsed in youth. We need not be ashamed of any such tendency to return—of such was Einstein, who traced his interest in the theory of gravitation to his objections as a schoolboy to the illogical way he was taught in mechanics to divide by '*g*'!

More often, however, the engineer finds new problems press upon him so much throughout life that the youthful ones are put aside unsolved. In approaching new design problems, if we are at all research minded, we commonly take one of two lines : either we struggle to get up-to-date with existing relevant research and use that information to the best of our ability in our new designs, or, having got as up-to-date as possible, we are still dissatisfied with our knowledge and seek ways, usually theoretical, of extending it for our particular design problem. The outlook here expressed is, and always has been, the strength

of the consulting engineers of this country. It is a habit of mind that grew up with the great engineers of the early nineteenth century—with Telford, Brunel and Robert Stephenson—and has fortunately remained with us largely ever since. Telford, for example, when planning the Menai Suspension Bridge—a bridge of record span in its time—realised some of the limitations of the then existing catenary theory of a suspension chain. He wanted, if he could, to be able to adjust the section of the chains across the span so that the stress in them was approximately constant, instead of greatest at the towers as with a uniform chain. The mathematics of this problem was beyond his powers, so he consulted the then President of the Royal Society, David Gilbert, who produced the theory of the " cable of uniform strength " in its now well known form and published it in 1826, about the time when the bridge was completed.

In the same field, with the longer spans of later times, practical doubts arose about the effects of, and allowance for, the stretch of the cable itself, hitherto treated as inextensible. E. J. Routh, the famous Cambridge mathematician of the late nineteenth century, first solved the problem in precise form in 1891 ; but his solution was difficult to apply in design and approximate procedures, which can be checked for accuracy against Routh's exact result, have come into common use this century.

But we have in this tradition a weakness as well as a strength ; the organisation of our profession, as represented by the separate client, consulting engineer and contractor set-up, tends to prohibit research investigations around a design job from proceeding beyond extensions of theory into experiment. This was a weakness, though at the time and under the circumstances an inevitable one, of the designs of both the Menai and the Clifton suspension bridges ; in neither case was the possible stiffening effect of the deck structure fully appreciated. It awaited the model experiments of Peter Barlow, later to design the Lambeth Suspension Bridge, to show how great this effect could be. The simple theory of Rankine, first published in 1858 and till recently in so many of our text books, was based upon a knowledge of this model work.

It took all the forcefulness of Robert Stephenson to try to bridge this gap by combining, with himself, the mathematics of Eaton Hodgkinson and the experimental work of Fairbairn, in the design of the Menai Tubular Bridge ; and even then they missed the point made by Barlow's later model experiments in their debates on whether the tube should be supported by chains or not.

In recent times we have seen three modes of working developed that have helped, in part, to overcome this difficulty of conducting relevant experiments for design purposes. First, in the hands of large industrial groups, such as the railways or the electricity authority, full scale experiments have proved economically possible on structures likely to be repeated in great numbers. Of such are the steel portal structures for carrying overhead electric cables for railways and the steel towers needed for grid transmission lines, examples of both of which have been tested to destruction under representative loading conditions.

Second, in relation to the use of special products, such as cold rolled steel sections, in structures, industrial research and development associations have conducted full scale tests on typical structures. Of such, too, were the early tests on specialist forms of reinforced concrete beams and columns, and in the same tradition today are the full scale tests financed by the welding industry on welded steel frames.

But tests of this character, though often in collaboration with designers, tend to move out of their hands into the hands of research workers and naturally cease to have any one particular application in mind. Drawing and design office staffs can, and like to, play a part in the extension of their methods, and if they could do so directly, not only by theoretical work but by simple experiment, would welcome the opportunity. This has been the thought behind much of the model work of Professor Pippard in the last twenty years. In particular, his development of the use of plane deformable xylonite models of arches, frames, portals and the like has resulted not only in a valuable research tool, but also in a method of experimental analysis for routine use on the drawing board.

In the Development of Codes of Practice.

Largely again in the hands of consulting engineers and designers is the business of initiating and keeping up-to-date codes of practice for various kinds of construction in common use. Just as in the process of design itself, one cannot sit long upon a code of practice committee without realising the shortcomings of an existing code and wishing to find means of correcting or improving it. Out of such desires arises a more general form of research than is engendered by the needs of a particular design. Results of general applicability, at least in the special field of construction concerned, are sought. Moreover, since not one or two individual designers but many such are to be convinced by the research results, appeal to experiment becomes specially attractive.

It thus happens, though not universally, that university workers are to be found in evidence in this kind of research. A classical example of this was the work of Professor Andrew Robertson on the strength of steel columns, done at Bristol during the inter-war years. Conducted in conjunction with the Steel Structures Research Committee of the time, it comprised a valuable survey of existing strut formulae of a kind suitable for design use, a very careful series of experiments on model and full scale steel columns, and a final marriage of both theory and experiment into a simple strut formula—the Perry-Robertson formula—that has enjoyed much popularity with designers ever since.

More recently we have seen a similar development in respect of the lateral stability of beams and girders. Dr. A. R. Flint, starting upon this problem as a post-graduate student at Bristol, has with others gradually extended, by both theory and experiment, our knowledge of the nature of the problem until at last, following full-scale work at Christchurch, the old rules-of-thumb of the inter-war codes of practice have been replaced by the new more rational clauses. My own part in this has been only to strike an initial spark, but it has been a special pleasure to see brought to this useful design stage the solution of a problem that, in elementary form and with no experimental facilities, I once attempted myself in an M.Sc. thesis with little success beyond getting the degree !

But the work of forwarding the scientific background to codes of practice is by no means confined to university workers. From time to time quite major, as well as very many minor, contributions are made by consulting engineers who have become specially interested in a particular problem. We in this Institution have only to look back into the work of some of our leading members, both present and past, to realise this. Of great value to the reinforced concrete world, for example, have been the periodic incursions

of the late Dr. Oscar Faber. Most recent in our minds is perhaps his work on the behaviour of reinforced columns, again both theoretical and experimental, that led to the revision, in a fundamental sense, of our notions of the ultimate strength of a reinforced concrete column under the steady and long continued loads arising in a building. This work moved rapidly into our reinforced concrete code of practice and was, as you will recall, being followed by a new series of experiments on the effect of concrete around rolled steel columns at the time of Dr. Faber's death. A few carefully selected experiments, backed by a clear physical understanding of the problem and expressed by a simple theory, can indeed be powerful in the hands of an experienced designer.

In the Use of New Materials.

To historians of science, the main advances in our field seem to arise from, if not be caused by, the introduction of new materials; and there is, of course, a great deal of truth in this. Modern structural theory dates from the introduction of cast iron into structures and the study of beam theory that its use necessitated. The whole theory of frames can similarly be said to have grown up with the use of wrought iron bars as the tension members in timber trusses.

But there are some aspects of this linking of structural advances with new materials, natural enough to the historian, that any engineer who has been engaged in research bearing on new materials knows in his heart to be unreal and almost "phoney." We have, for example, seen since the war a great extension, starting from aircraft structures, in the use of aluminium alloys, and this has been accompanied by much research. The research work has been new enough and necessary enough indeed, but most of it could well have been done for structures in the older materials. Thus the gradual introduction of aluminium alloys into shipbuilding has been accompanied by some interesting researches into the buckling of plating and into the diffusion by shear of bending stresses in a ship's hull into its superstructure, but the actual results, though sought first to make safe the introduction of aluminium alloy, should have been known earlier for the better design of steel ships and are almost equally applicable thereto. In the same field, valuable experimental work has been done on the behaviour of riveted joints in light alloy plating, including some work on the effect of load on such joints on their liability to permit the leakage of water through them; but much of this work, though specially needed for the new material, in an ideal world would have been done long before with the traditional materials.

This feature of research work for the use of new materials is very general. I myself am concerned at the moment with some work involving the resistance of plated structures to impact loads such as arise in railway accidents, starting on the problem with a view to contributing to the design of light alloy vehicles generally; but, of course, much of the work will be equally relevant to steel vehicles and in that sense should have been done long before. We can indeed go back to my first example, the development of beam theory around the use of cast iron, and in the same way say that the whole of the theory could have been developed for the earlier timber beams.

In this sense, therefore, research around new materials is the benefactor, as it were, of traditional or backward industries. But, of course, there is more in it than this. My cast iron example itself makes the point: one reason why beam theory was so hesitant prior to experiments with cast iron was the absence, theretofore, of experience with beams of a material having very different strengths in tension and compression. In the same way, the great value of aluminium alloys to the general advancement of structural knowledge lies in the fact that it is a material of much the same strength as structural steel but of only one-third the stiffness; and hence our new preoccupation with buckling in compression and shear, and modes of design to control or postpone it.

Our own Institution grew out of the development of reinforced concrete as a new structural material; what a wealth of research work its use has involved and how much of it has added to our understanding of structures in general—beams, arches, shells and monolithic frames. Yes, historians may not understand the details of the process, but they are right in pointing to the importance of new materials for the development of the structural art. And those of us in the universities who are specially concerned to try to advance the science of structures should, and I hope usually do, jump at the opportunities, much wider than are immediately apparent, provided by the use of a new material.

On the scale required for most of our structures we cannot expect to use materials that are so new as to be like precious metals and suitable only for small but essential parts of gas turbines or nuclear power equipment. But let us remember that aluminium was once a precious metal, and not overlook the properties of new materials that, if they become popular, are likely to fall greatly in price; let us note, for example, the strength and thermal resistance of titanium, and the great strength and stiffness—its E is 50 per cent above that of steel—of beryllium. These may not be the materials of a future structural age, but we often want greater strength or stiffness, or both; and how useful could be a material immune to ordinary fire hazards or one with zero coefficient of expansion. It is not only new materials in the ordinary sense that may come to be of most value; old materials in quite new forms may yet emerge. The science of metal physics is today astir with new possibilities of great potential for our art.

In Pioneering Projects.

We usually regard the nineteenth century as the age of large pioneering structures; we think of the early suspension bridges of Telford and Brunel, of the latter's "Great Eastern" liner, and of the Britannia Tubular Bridge of Robert Stephenson, and tend to regard our own opportunities as much more circumscribed. But each generation usually has such a chance and, when it has, is measured in history by its response; and if we look at structural work in this century there have been examples that, if not so renowned or successful as the earlier ones of Victorian times, have at least led to great strides in our art.

When I was a student I read every technical article I could acquire about the then proposed Sydney Harbour Bridge and later about its design and construction. Many of my contemporaries no doubt did the same and wished, as I did, that they were a little older and could take at least a small part in so stirring a work. The older men responsible—Sir Ralph Freeman and Dr. J. J. C. Bradfield—have now left us, but one has only to read a recent popular description by H. Shirley Smith, once a junior on its design, to realise what an inspiration it was to those who worked on it as well as to British structural engineers generally.

In the background this major effort drew forth some research contributions. I was dimly made aware, even as a young onlooker, of what a highly redundant structure could mean in the matter of strength calcu-

lations ; and those who took part in the work learnt many lessons later to bear fruit in other fields.

On the experimental side there came into being the Dorman Long 1250 tons horizontal testing machine, designed initially for testing large scale models of struts used in the bridge arch. This machine, which thus played a part in ensuring the safety and efficiency of the bridge, has contributed usefully to many other projects since, including the great Bristol Brabazon aeroplane. Modelled in many respects on the earlier 300 ton machine at Birmingham University, its dramatic partial failure during a proving test so impressed Professor Batho of Birmingham that even 30 years later he could relate every detail of the event, including the personal reactions of those present !

But the movement towards increased research effort in structures that has become so noticeable in recent decades was as yet hardly under way and the volume of research behind the Sydney Harbour Bridge was almost negligible on modern standards.

During the 1914-18 war the British people had been greatly impressed with the performance of the German Zeppelins, and it was thus natural that, when the government sought to speed up Empire communications, they should think of airships. In the early 1920s the ranges of passenger carrying aeroplanes were negligible compared with those possible with airships and the famous Graf Zeppelin was already being planned. There thus came into being a British scheme for building large airships, much bigger than those of the war, for Empire communications, and the R 100 and R 101 were to be the pioneers in this role. Again, even more than the bridge project, the construction of such dream-like structures caught the fancy of young engineers of the time as well as that of the British public ; and in this case more time and money were spent on research and, in spite of the failure of the project itself, greater benefit resulted to the structural art in general.

Work on both ships proceeded much in the classical tradition of Robert Stephenson and his Britannia Bridge. Col. V. C. Richmond, the designer of the R 101, for example, was backed by Professor, now Sir Richard, Southwell, as a consultant, by J. D. North and Dr. Aitcheson on the construction and metallurgical sides, as well as supported by a team of eager young graduates caught by the interest and glamour of the project. And all were subject to the airworthiness surveillance of Professor, now Sir Leonard, Bairstow and Professor Pippard. This galaxy of talent, coupled with opposite numbers in the light alloy and aircraft industries and in the National Physical Laboratory and the Royal Aircraft Establishment, Farnborough, left their mark on structural theory and practice. The theory of space frames advanced apace. The principles of designing struts to carry given loads over given distances with the expenditure of as little weight as possible developed to a stage that has since blossomed in the work of Shanley and others in America, and A. E. Russell and H. L. Cox in this country. The aluminium alloy industry, previously struggling to provide for domestic articles as a background to a few aeroplane applications, made great strides both in its products and their applications. X-ray photography, in its application to the examination of metal parts, stepped for the first time out of its beginnings in gunnery to the examination of light alloy castings all over the R 101. Furthermore, the 1250 ton machine at Middlesbrough was exceeded in usefulness by the lighter but much more flexible 100 ton machine at Farnborough, capable of testing, under end load and lateral load, struts up to 100 ft. long. Into each of these gossamer airship structures, the size of a large 40,000 ton liner, were woven duralumin tubes and plating, 60 ton steel tubes, 100 ton steel cables and many light alloy stampings and castings, all to form a structure weighing less than 100 tons. Structural engineering, in its aeronautical application, suddenly grew up.

I have said enough to point to the research contributions that major pioneering projects can bring about. The advancement of structural theory, the development of laboratory equipment and techniques, and the gathering together and sharpening of the wits of research workers by the impact of large scale inspiring events, all emerge. What are we doing in our own generation ? May we not be seeing the beginnings of new events of like import, equally attractive to able young men, in Calder Hall and in the latest projects for nuclear powered oil tankers of unusual size ? This generation seems about to have its major chances.

In the Universities.

From the hurly-burly of practical research let us turn a moment to something more leisurely and academic, even though the latter term, among engineers, is often used in a disparaging sense. It is commonly used in reference to university research, particularly when of an idealised and theoretical kind, and so seemingly unlikely to be of use in current practice. It is not only practical engineers of the hard school who hold a poor view of such academic work : young graduates, after a few years' experience in the field, are often so impressed with the hard realities of engineering life that they become very critical of the theory learnt as undergraduates and eschew it for years afterwards. Some, indeed, never recover their youthful interest ; but most of us, I think, ultimately regain some interest in engineering theory, albeit from a more balanced viewpoint.

I have no intention here of apologising for such academic work ; like other forms of work, the best is often unexpectedly fruitful, sometimes a hundredfold, while the worst is useless. I want instead to argue here in favour of good academic work even when it is deliberately undertaken without regular or immediate contact with practice ; to argue, in fact, that in many cases abstention from too frequent contact with practical applications is, in the long run, a good thing for all concerned.

Let me take as a first example, and one very relevant to our field, the development of that method of engineering analysis known as " Relaxation," for which we have specially to thank Sir Richard Southwell. I happen by chance to have seen the beginning of this work. I was interested at the time in the problem of finding the bending moments at the ends of the members in a stiff-jointed space frame—a very highly redundant structure—and was referred by Professor Pippard and J. F. Baker, the latter then at the Building Research Station, to the first paper by Hardy Cross on the simpler, but related, problem of the moments in unbraced portals. As a result, Baker and I wrote a short (unpublished) note on the possible relevance of the Hardy Cross successive approximation process to the space frame problem. As Professor Southwell said in his first paper on relaxation, it was through this note that he learnt of Hardy Cross's work ; it thus became part of the background to the initiation of the relaxation process. I recall that, as soon as Professor Southwell had made progress with his method, I was anxious to ply him both with practical aero-

nautical examples for solution and with further information on applications and developments of Hardy Cross's work. But I remember very clearly—it impressed me at the time because, in my inexperience, it surprised me—that Southwell, instead of thus interesting himself, said he wanted to " put his head in the sand " and get on uninterruptedly with the job of advancing the development of the relaxation process, in which he saw from the start great potentialities and widespread applications. With the greater pressure of more recent times, experienced university men have come more and more to value and to long for opportunities to " put their heads in the sand ! " Indeed, I have tried it myself, perhaps for shorter periods and certainly with much smaller results.

As we can see now, over the years Professor Southwell's team was developing and marshalling a mathematical process in which the steps were linked with physical ones of a kind that appeal to engineers and physicists, in both of whose domains relaxation has made a lasting impact. Out of the " sand " has emerged something we can all use, at least in moderation, and something that, in the hands of better users than ourselves, has produced results of much practical value and interest.

Another example, quite different in kind, yet linked with the foregoing in its " academic " nature—its refusal, in its early development, to take much notice of current practice—is seen in the background work to our Institution's recent report on the safety of structures. We are, of course, here looking at a development in a much earlier stage than relaxation now is, after its 25 years of history, and a development with origins not, apparently, in one spot but in several, all within the last 15 years.

That the strength of a structure, made to a given specification and to given drawings, could not be precisely predicted has, of course, long been realised. That if several such structures could be tested to destruction their breaking loads would not be the same but would show a scatter about a mean value was also realised, and both scatter and mean have sometimes been evaluated in mathematical terms. The germ of the new background to the philosophy of structural safety came into being with the further realisation that the external loads on structures in real life, in nature, could also be thought of in terms of mean loads and the scatter about them, and that, by doing this, load information could be coupled with the similar strength information to predict an accident rate for the structure under its real variable conditions. At last the risk involved in the choice, say, of a low load factor, or in the use of a high working stress, could be assessed qualitatively and, with sufficient data, quantitatively.

There was not here the development of a new mathematical process ; rather it was that, given a few new ideas, all the mathematics of the established theory of probability suddenly became relevant and available with a rush to the elucidation of an old structural problem. The work has not, of course, stopped at the static strength problem discussed in our report ; the safety of structures in fatigue can be discussed on similar lines and the whole theory can be related to the essential connection of all ideas of structural safety with both human safety and financial economy. Here is a great body of theory building up, largely so far without direct influence in practical engineering save in aeronautics, that is slowly producing a new outlook, a new climate, in which to consider safety questions. A later generation, bred maybe in this country, or in France, Norway or in the U.S.A., will grow up in this climate at the universities and come to use some of the new ideas in practice and give them real life.

If the universities of the future ever fail to give shelter, and a little peace, for the development of such " academic " ideas, they will have indeed failed the engineers and, through them, the people of their time. That our Institution, a professional body, should have already given great encouragement to this work, is a matter for pride in its youth and vigour.

Conclusion.

Looking back over the examples of research I have quoted, one realises how much the structural engineering of the first half of this century has been characterised by its increased use of mathematics. The seeds of this process were set last century when Telford appealed to Gilbert about catenaries and Robert Stephenson had his experiments, and those of Fairbairn, analysed by Hodgkinson. But now the engineer not only employs mathematicians, he thinks in mathematical terms himself. Thus he comes to absorb new scientific developments, for use both in his researches and his practice, most readily when they have been stated in simple mathematical ways. To the research worker in structures, mathematics is now more than a tool : it is a habit of mind and a major mode of understanding.

Another general point affecting this century's advances in our science concerns the part played by experiments, particularly on a laboratory scale. Accustomed as we are today to see well-equipped material and structural laboratories in industrial research associations and most universities, it is difficult to realise that the first commercial " testing house " built by Kirkcaldy in 1866 remained a lonely example for many years and was not followed by university laboratories till those of Kennedy at University College, London, in 1878, Unwin at Coopers' Hill in 1883, and Hele Shaw at Bristol in 1883. And their equipment was extremely meagre for many years thereafter, consisting principally in each case of one testing machine. It was the two wars of this century that were largely responsible for giving structural testing a new impetus and range, so that it is now a settled and growing habit of research workers and designers alike.

To these wars engineering in this country—and structural engineering is a good example—owes much more than its structural testing facilities. The give and take between different fields of science and engineering, and between individual scientists and engineers, brought together by the exigencies of war, has resulted in a marked acceleration of our affairs ; here is a basic source of new ideas and new practices. There are evidently great advantages in periodically taking the ideas and methods of one science into the work of another, and our wars have forced this mixing process. The advances we have witnessed in practice this century owe much to this mixing ; the process is not a new discovery, it is the traditional custom of the university common room, writ large.

We have lived, and live, in rapidly moving times. The research effort in our field today is many times what it was at the beginning of this century, and yet is still small compared with that in some other fields of engineering endeavour. If this brief survey of the way of research is found a source of interest and encouragement, however small, then it has done a little towards the object of all our researches—" the advancement of the science and art of structural engineering "—and I am indeed well satisfied.

Structural Features of the new Binns Store in Middlesbrough*

By F. R. Bullen, B.Sc., M.I.Struct.E., M.I.C.E. (Hon. Treasurer).

Fig. 1.

THE subject of this paper is a new departmental store in Middlesbrough for the firm of Binns (Sunderland) Ltd., a member of The House of Fraser. The building is of large proportions and fronts Newport Road with return frontages to Linthorpe Road and Newport Crescent. The shape of the site is in the form of an "L" and the rear boundaries consist of the Imperial Hotel and the Café Royal.

Fig. 1 shows an external view of the building prepared from the Architect's original drawing. The building is mainly of Portland stone and has Broughton Moor slate facings about the windows. The length along Newport Road is 159 ft. at ground level and the height is approximately 90 ft. to roof. It is framed in steel and is supported upon reinforced concrete piled foundations. There is a basement above which are the ground floor and five other floors as well as the roof.

Work on site was commenced in August 1954 and the store was opened to the public in March 1957.

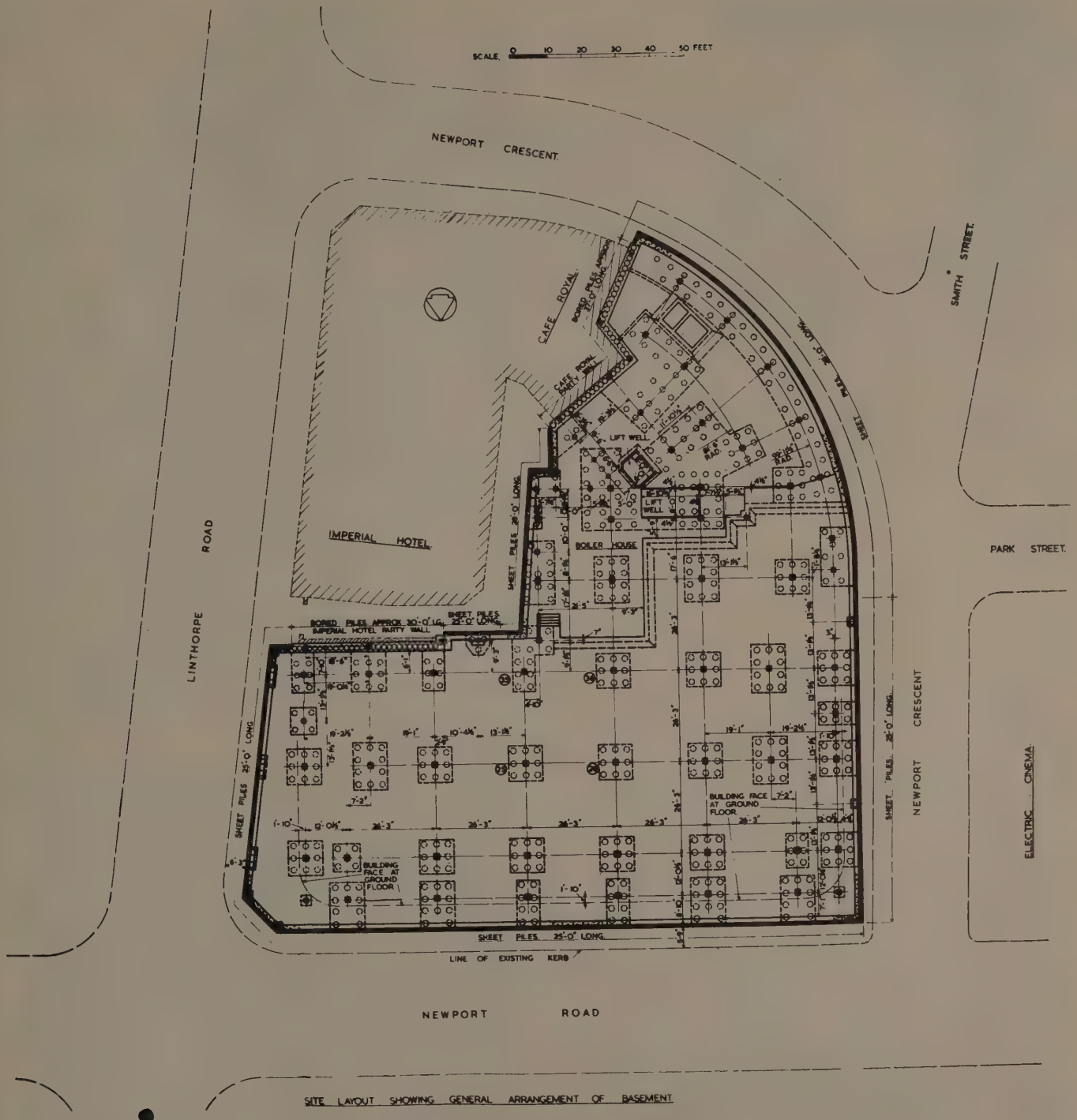
The principal structural features which will be referred to in this paper are the reinforced concrete foundations and basement construction, the structural steel framework and steel deck floors, and the reinforced concrete staircases. It will be appropriate to describe these features in that order.

There had been on the site previously a departmental store owned by Binns Ltd., but it was some years old and had been burnt down by fire (not due to enemy action) during the war. The site had been in use temporarily for a British Restaurant and when the new development was proposed the British Restaurant had to be transferred to another site further along Newport Road.

It may be remarked at this stage that the main factors which had to be borne in mind throughout the design and construction were the restricted size of the site, the limited access and the difficulties generally of building within a busy area where the adjoining roads are full of continuous vehicular and pedestrian traffic.

Fig. 2 shews a plan of the site and from this may be seen the surrounding roads and the relative positions of the adjoining Imperial Hotel and Café Royal. Both Newport Road and Linthorpe Road are main thoroughfares and in addition the part of Newport Crescent facing the new building is used by many of the local 'bus routes which terminate at the Bus Station in Park Street. The Electric Cinema is also shewn. It will

* *Paper to be read before the Institution of Structural Engineers at 11, Upper Belgrave Street, London, S.W.1., on Thursday, 14th November, 1957, at 6 p.m.*



SITE LAYOUT SHOWING GENERAL ARRANGEMENT OF BASEMENT

Fig. 2

be appreciated immediately how difficult was the access to the site and how much effect this had upon the progress and the cost of the work.

As early as it was possible to make such arrangements, two boreholes were put down on the site to obtain information about the ground conditions. These two borings revealed that the site consists of a mottled laminated clay with thin layers of sand overlying two further beds of clay which are also laminated but to a less degree. Below these beds lies boulder clay. The strata overlying the boulder clay are essentially the same, the only differences being the colour and the degree of lamination. They are classified as "clays of high plasticity." The shear strengths are low, not exceeding 11 lbs. per square inch; consolidation tests indicated a highly compressible material. Table I gives details of the properties measured from samples taken from these clays.

Table I.

Liquid Limit	from 56 — 62%
Plastic Limit	26 — 28%
Plasticity Index	30 — 35%
Water Content	31 — 35% (Exceeds plastic limit)
Wet density	122 — 123 lbs. per cu. ft.
Dry density	91 — 95 lbs. per cu. ft.
Shear strengths	7 — 11 lbs. per sq. inch.
Remoulded strength	4 lbs. per sq. inch.

Table II shows the results of a consolidation test on a sample of such clay and indicates the compressible nature of this soil.

Table II.

Pressure increment tons/sq. ft.	Coefficient of Consolidation c_v (sq. in/min × 10-4)	Coefficient of Volume Compressibility mv (sq. ft/ton).
0 — ¼	—	0.041
¼ — ½	—	0.036
½ — 1	42.6	0.037
1 — 2	24.1	0.024
2 — 4	35.2	0.016
4 — 8	46.2	0.011

On the other hand, the boulder clay is a stiff dense soil and is classified as a "medium plastic clay"; it has a shear strength of about 20 lbs. per square inch, and is much less compressible than the softer clays above. Table III gives details of the properties measured from samples taken from this boulder clay.

Table III.

Liquid Limit	37%
Plastic Limit	19%
Plasticity Index	18%
Water Content	14 — 19% (less than plastic limit)
Wet density	134 — 137 lbs. per cu. ft.
Dry density	113 — 116 lbs. per cu. ft.

Table IV shows the results of a consolidation test on a sample of the boulder clay; it will be noted that it is much less compressible than the softer clay above.

Table IV.

Pressure increment tons/sq. ft.	Coefficient of Consolidation c_v (sq. in/min × 10-4)	Coefficient of Volume Compressibility mv (sq. ft./ton).
0 — ¼	—	0.033
¼ — ½	—	0.033
½ — 1	77.0	0.026
1 — 2	78.5	0.015
2 — 4	78.5	0.009
4 — 8	96.5	0.007

Various foundation schemes were investigated and in principle a raft was to be preferred. One reason for this preference is that a raft tends to prevent relative movement between various features of the structure and is often more successful on that account where waterproofing is important. On the other hand, a raft requires reasonably close spacing of columns to make it an economical proposition. Where the column spacing is large and consequently the column loads are relatively large, the raft has to be made so thick as to render it an uneconomical method of construction. A further factor in this type of foundation is the level at which the firm material is found and the nature of the material immediately over, which may have to be used to support the loads from the raft. In the present case, the clay with sand layers which overlies the firm boulder clay contained sufficient problems on account of the sand layers as to cast doubt on the wisdom of placing upon it heavy loads. This clay is a quite remarkable material; it would seem to be of recent origin but nevertheless when excavation was in progress the clay was found to be stiff enough to justify the use of mechanical tools. At one stage the clay actually supported the leg of one of the derricks used for erecting the steelwork. Nevertheless, due to the presence of the sand layers the shear strength was low and the behaviour of the material was difficult to forecast. From time to time water was found to be percolating through the sand layers and its action upon the clay would obviously be fundamental. In all these circumstances there seemed to be no alternative to supporting the structure upon piles, such piles being installed sufficiently into the boulder clay to carry the necessary loads. On a site such as this the use of precast or other driven piles was not practicable by reason of the effect on the nearby buildings and bored piles were used.

The original intention was to use bored piles which would carry 40 tons each and the first pile put down on the site was chosen to act as a test pile. This pile was installed to a depth of 10 ft. into the boulder clay and subsequently tested by a load obtained from an hydraulic jack re-acting against kentledge supported over the pile. The data of this test are shewn in Fig. 3a. As a result of this test it was decided that the piles so arranged would not achieve as much support as had been anticipated and the design load was reduced to 35 tons per pile. Some calculations were made to discover the economics of sinking the piles lower and putting 40 tons on each, but it was found that the general arrangement of the column loads caused a pile load of 35 tons to be the most economical. This is an interesting fact; it follows that the design load per pile needs to be carefully considered in relation to the superstructure loads and the installation costs as well as the conditions of the site. It is sometimes necessary in order to achieve a symmetrical pile arrangement to add one or two extra piles to a pile group and if advantage be taken of these piles then clearly the load per pile is less. In such a case it would be uneconomical to install longer piles capable of taking the larger loads. It is perhaps of interest to note that the method of calculation suggested by Dr. Golder and Mr. Leonard gives a value to the first test pile of 85 tons which is very close to the actual ultimate load measured.

Another pile shewn in Fig. 3b was selected for testing during the course of the work and this also shewed a similar result so that the decision to design to a working load of 35 tons was well substantiated. According to these settlement diagrams the settlement

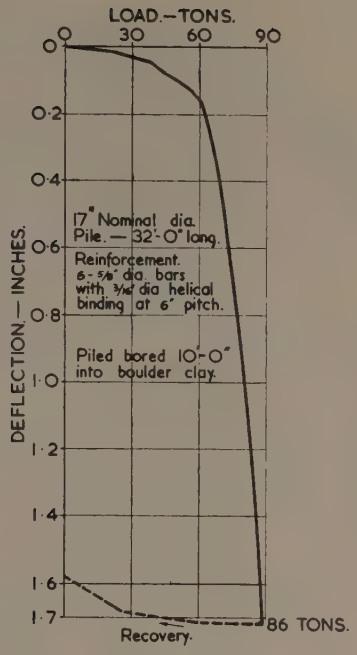
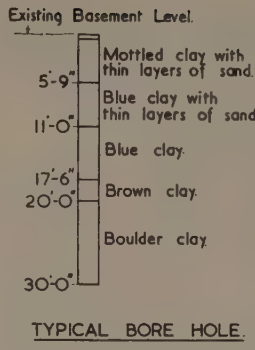


FIG. 3a.



TYPICAL BORE HOLE.

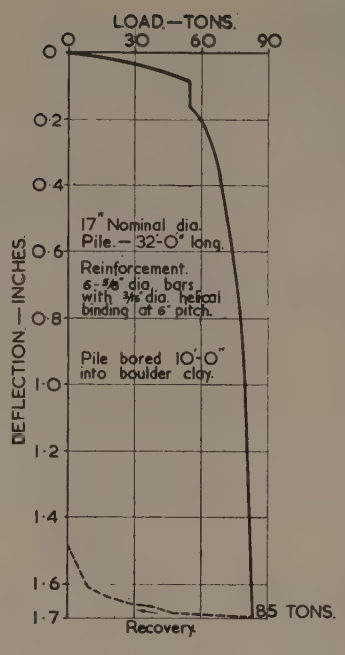


FIG. 3b.

Fig. 3

to be expected under a working load of 35 tons appears to be of the order of .04 inches.

It may be of interest to observe that the simple expedient of dividing the column load by 35 was used to determine the number of piles necessary ; owing to the stiffness of the pile caps, no more complicated calculations were made than this. The nominal diameter of the piles was 17 in. ; the reinforcement consisted of 6 bars $\frac{5}{8}$ in. diameter with $\frac{3}{16}$ in. diameter helical binding at 6 in. centres and the concrete was a 1:1½:3 mixture. There are, in all, some 467 load bearing piles and 71 in underpinning.

Referring again to Fig. 2, attention may be drawn to the proximity of the Imperial Hotel and the Cafe Royal since, as will be described later, both these buildings had to be underpinned. The basement of the new building is approximately 15 ft. below road level, that is to say some 5 ft. or so below the basement of the previously existing premises. In consequence, new retaining walls had to be built around the perimeter of the site ; the old walls whilst adequate for their particular purposes were quite inadequate for the new construction and were removed. The new retaining walls were built of reinforced concrete and after very careful consideration it was decided to build these within a surrounding curtain of steel sheet piling. One of the major considerations in the choice of this method of construction was the security of the three roads around the site. The traffic along all these is considerable and in addition public utility services lie under the pavements. It follows, therefore that no movement in the ground could be tolerated and even timbering would have given rise to potential dangers. In the event, the steel sheet piling proved to be a safe, simple and satisfactory method of construction.

Fig. 4 shews some typical cross sections of the site and gives the relative positions of the steel sheet piling, the new basement floor, the pile caps and piles and several other features. The choice of section for the steel piling in such conditions is always difficult ; the difficulty lies in finding a section which, whilst economical in itself, does not require uneconomical temporary supports. Alternatively, if the sheet piling is made too strong thereby reducing the temporary supports to a minimum the piling itself becomes uneconomical. Other considerations such as the flimsiness of the piling having regard to its length also require consideration and the general properties of the piling in relation to the ground through which it is to be driven must be carefully considered. The section chosen in the circumstances was Larssen No. 1U ; the length generally was 25 feet, but in the deeper basement areas the length was increased to 28 feet. Some engineers may feel that the section used was perhaps lighter than these lengths would suggest, but the general arrangement of the piling and particularly the temporary strutting made this section the economical one.

The method of procedure was broadly as follows. The steel sheet piling was driven around the perimeter of the site and as soon as it had proceeded far enough the dumpling piling was commenced. The usual description of the ground enclosed within the inner line of steel piling is the " dumpling " and the purpose of the dumpling is to provide support for the temporary

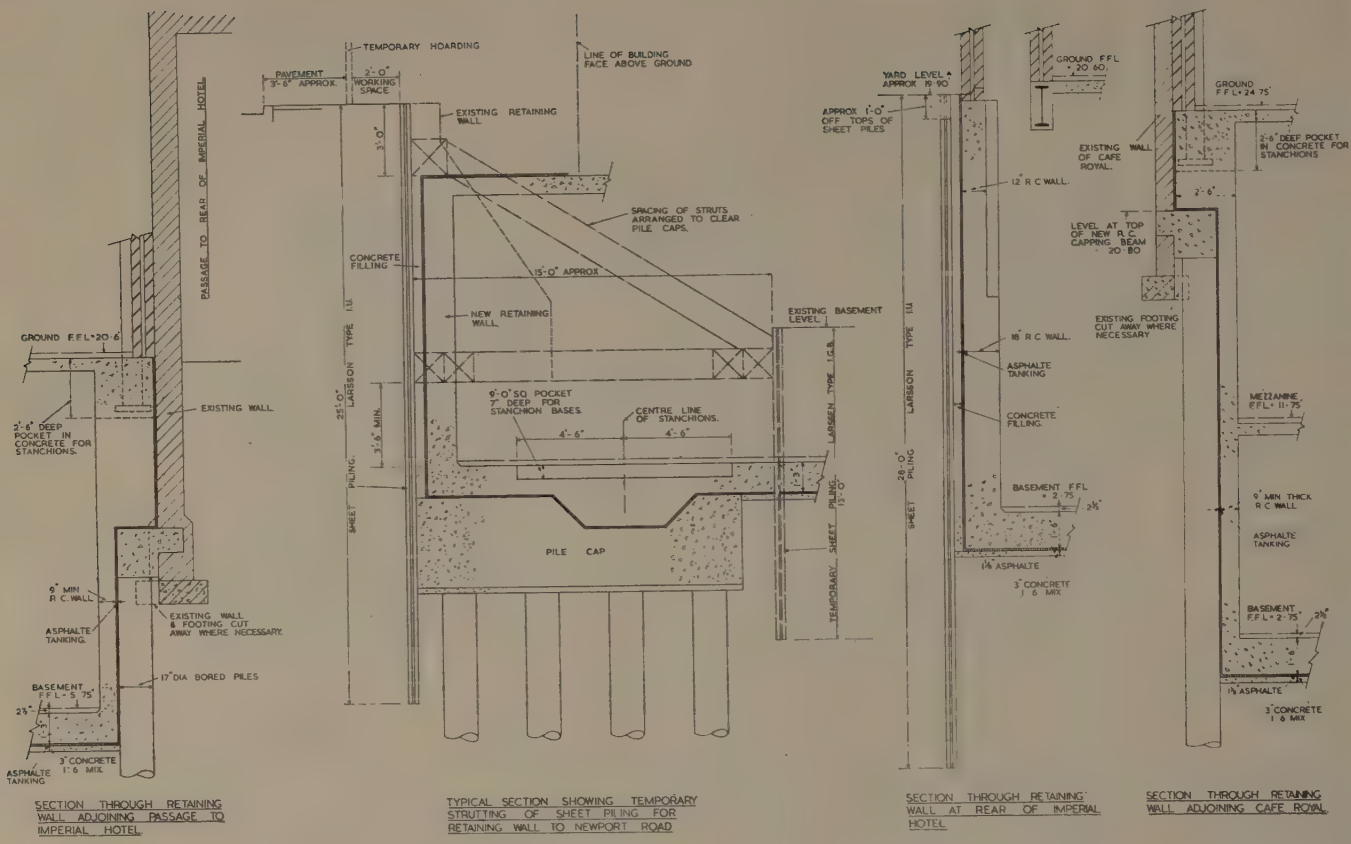

TEMPORARY HOARDING
LINE OF BUILDING FACE ABOVE GROUND
PAVEMENT 3'-6" APPROX.
2'-0" WORKING SPACE
EXISTING RETAINING WALL
3'-0"
SPACING OF STRUTS ARRANGED TO CLEAR PILE CAPS.
CONCRETE FILLING
15'-0" APPROX
NEW RETAINING WALL
EXISTING BASEMENT LEVEL
PASSAGE TO REAR OF IMPERIAL HOTEL
GROUND F.F.L.+20·6
EXISTING WALL
2'-6" DEEP POCKET IN CONCRETE FOR STANCHIONS.
25'-0" LARSSEN TYPE IIA SHEET PILING
3'-6" MIN.
9'-0" SQ. POCKET 7" DEEP FOR STANCHION BASES.
CENTRE LINE OF STANCHIONS.
4'-6"
4'-6"
LARSSEN TYPE IIA
PILE CAP
TEMPORARY SHEET PILING 15'-0"
9" MIN R.C. WALL
ASPHALTE TANKING.
EXISTING WALL & FOOTING CUT AWAY WHERE NECESSARY.
17" DIA BORED PILES
BASEMENT F.F.L.+5·75
2½"
3" CONCRETE 1:6 MIX
ASPHALTE TANKING
SECTION THROUGH RETAINING WALL ADJOINING PASSAGE TO IMPERIAL HOTEL
TYPICAL SECTION SHOWING TEMPORARY STRUTTING OF SHEET PILING FOR RETAINING WALL TO NEWPORT ROAD
YARD LEVEL APPROX 19·90
APPROX 1'-0" OFF TOPS OF SHEET PILES
20'-0" LARSSEN TYPE IIA SHEET PILING
GROUND F.F.L. +20·60
12" R.C. WALL.
18" R.C. WALL.
ASPHALTE TANKING
CONCRETE FILLING.
BASEMENT F.F.L. +2·75
2½"
1½ ASPHALTE
3" CONCRETE 1:6 MIX
SECTION THROUGH RETAINING WALL AT REAR OF IMPERIAL HOTEL
EXISTING WALL OF CAFE ROYAL.
GROUND F.F.L.+24·75
2'-6" DEEP POCKET IN CONCRETE FOR STANCHIONS
2'-6"
LEVEL AT TOP OF NEW R.C. CAPPING BEAM 20·80
EXISTING FOOTING CUT AWAY WHERE NECESSARY
MEZZANINE F.F.L.+11·75
9" MIN. THICK R.C. WALL
ASPHALTE TANKING
BASEMENT F.F.L.+2·75
2½"
1½ ASPHALTE
3" CONCRETE 1:6 MIX
SECTION THROUGH RETAINING WALL ADJOINING CAFE ROYAL

Fig. 4

Fig. 5.

struts used to uphold the outer steel sheet piling. The dumpling piles consisted of No. 1 G.B. Larssen piles in 13 ft. to 17 ft. lengths. They were driven down until their tops were about level with the ground which, at that stage had been reduced to the previous basement level. The top walings and raking struts of the trench excavation could then be put in, and when these had proceeded far enough, the bored piling commenced. The bored piles were bored to the appropriate depth, namely, about 10 ft. into the boulder clay and were concreted only up to their final levels within the pile caps.

Fig. 5 shews the external steel piling, the dumpling piling and the temporary timber strutting used to uphold the perimeter sheet piling. It also shews bored piling in progress. As may be noticed, the walings supporting the perimeter piling were made of steel joists, whilst the struts supporting the walings were in timber. The levels of the walings and struts were regulated by the requirements of the reinforcement in the retaining walls. The positions of the struts in plan were also regulated by the pile caps. In consequence of this, the original drawings, whilst they did not tie the contractor to any specific method of strutting, did shew suggested positions and drew attention to the need for care in placing the struts relative to the permanent construction. In addition, close collaboration existed between the contractors' agent on the site and the engineers' designing staff in Darlington to ensure that the detailed drawings did not create undue problems for the contractors.

When the two lines of steel piling had been completed excavation proceeded in the trench between the two as far as it was safe and practicable so to do by machine. Following this the remainder of the excavation had to be done by hand and ultimately the pile caps were entirely excavated by hand. At this stage the tops of the piles were revealed; the pile caps were then prepared, reinforced and concreted. Every effort was made to concrete the pile caps as early as possible since this arrangement possessed the great merit of securing proper stability of the lower ends of the perimeter steel piling and thus the security of the site was maintained. After the pile caps within the trench had been completed the ground between them was levelled and covered with a 3 in. thickness of weak concrete. This concrete was intended to be laid to clean up the site and to form a base for the asphalte damp course. In practice, the contractors found it an advantage to lay this concrete prior to the construction of the pile caps and to use it as a setting out platform for the pile caps. It proved to be extraordinarily satisfactory and as a result the site was clean and tidy and very well organised. It also had the additional merit of protecting the edges of the pile cap excavations which are points where normally the ground becomes irregular and untidy. It is fair also to say that the 3 in. concrete lent support to the steel sheet piling as well.

It may be noticed from the sections in Fig. 4 that the pile caps were dished to receive the holding-down bolts of the stanchions. Obviously there is no uplift on these stanchions in their final positions, but during construction it is possible that some other forces might arise and in any case the bolts act as means of locating the stanchions. Over these dishings and over the whole of the site was laid an asphalte membrane; great care was taken of this, particularly at the junctions between the pile caps and the 3 in. thickness of concrete. The arrangement is not an ideal one since the reinforcement in the pile caps is not within the asphalte membrane; nevertheless, it is almost impossible to bring the pile cap reinforcement inside the membrane and, indeed, the only method which has been used has involved forming asphalte "stockings" around the upper lengths of the piles. With the arrangement used and described the bulk of the structure is protected from water attack. On account of the delicacy of the waterproof membrane, the reinforced concrete basement slab overlying it was carefully reinforced top and bottom and was arranged so that it would span from pile cap to pile cap without undue deflection. It was intended by this means to avoid fracture of the membrane.

It is permissible here, perhaps, to comment that this problem does not arise when a reinforced concrete raft is used covering the whole site. In such a case the raft can be made fairly thick and in consequence the likelihood of flexure in any part of it is much reduced with less likelihood of the asphalte becoming fractured. For this reason a raft is desirable, but as described above there are other factors which enter into the ultimate decision and in the present case these far out-balanced the asphalte requirements.

Some reference has been made already to the underpinning of the Imperial Hotel and the Café Royal; both these buildings are important in themselves, although both are much smaller than the new structure. Both buildings had foundations which occurred at levels much above the level of the new foundations of the new structure. Accordingly, it became necessary at as early a stage as possible to secure the stability of the foundations and the buildings over them. Various methods were considered; for instance, the customary method of putting in needles supported upon the nearby ground was one method; underpinning in short lengths by mass concrete taken down to an appropriate depth was another method which received consideration. For the Café Royal, whatever method was used had to be one which would not interfere with the inside use of the building. This requirement did not apply quite so literally to the Imperial Hotel since immediately adjacent to the site was a roadway and not a series of rooms. Any of these methods would have been expensive and whilst they are well tried they do entail some risk of fracture; fracture can be prevented if the work is done by a jacking process but the cost can be high. Once again the economics of the matter were very important. The method chosen after very careful consideration was to install along the faces of the walls of these buildings continuous rows of bored piles. The piles were installed practically touching each other and after they had been completed an eccentrically arranged capping beam was constructed over the piles and tucked into a chase cut out of the brickwork foundation of the walls. In order to construct this beam, the full thickness of the wall was cut away for a short length and into this was cast the reinforced concrete capping beam. It was thus possible to take up the weight of the buildings upon the new continuous row of bored piling without in any way endangering the structures or going inside them to do the work. The beams could be formed in sections of appropriate length and the whole arrangement was efficient, safe, economical and unobtrusive. It had the further merit that when the load of the existing structure came upon the new construction it acted as a stabilizing force against the outward pressure of the retained ground beneath and advantage was taken of this when the nearby excavation was taken out. Further

to these advantages, the piles were also used for carrying the loads from the permanent structure of the new building and thus it was that they performed three functions and a safe, practical and economical method resulted. Under such conditions the actual vertical load per pile was reduced to about 20 tons. Fig. 6 shews the piles used to underpin the Café Royal. As may be seen, the method was not strained unduly and when excavation had proceeded to a certain depth temporary struts were placed against the capping beams to ensure that they were not pushed out by the active pressure of the ground behind them. It may be of interest to recall that consideration was given to installing some of the underpinning piles to the full depth for the purpose of carrying only vertical load and leaving the others at a higher level to act only as retaining piles. Due to the distribution of the various loads, however, it was ultimately decided to treat all piles as load bearing and accordingly, they were all installed 10 ft. into the boulder clay.

Fig. 6.

It is no exaggeration to say that the drawings and photographs scarcely do justice to the difficulties of the work on site. The confined and almost unapproachable site made the work both difficult and costly, but it is worth recording that the good-will of all concerned, not excluding the United Bus Company and the Police as well as the general public, enabled the work to proceed safely.

The superstructure of the building is supported on just over 1,000 tons of structural steel. The external cladding, consisting of Portland Stone on brickwork backing, imposed fairly heavy loads both on the superstructure and the foundations. In addition, the demand for uninterrupted floor space on each floor dictated a wide column spacing and the principal grid is 26 ft. 3 in. square. With spans of this order carrying reasonably well loaded floors the weight of the structure and the weight of the floor construction is important. The loads involved on these spans were such that using normal precast concrete floors with encased steel beams the structural steelwork became rather heavy and built up or at least compound sections were necessary. Accordingly, steps were taken to reduce the dead loads and it was found possible by omitting the concrete encasing to the steelwork and using light steel decking for the floor decks to change the compound beams to simple joists. The effect of these savings in weight was to reduce the weight of steel by some 10 per cent, a not inconsiderable saving; a complementary effect was the saving in weight of structure and of foundations.

The steelwork generally is designed in accordance with B.S. 449 and involves little more than normal beam and column design. A number of difficult features arose, however, such as the need for wide spans to the ground floor windows, the curved corners with the resulting curved canopies and sundry complications of that kind.

Fig. 7 shews a typical cross section of the Newport Road frontage and illustrates the features of the structure in these respects.

The main problems associated with the steelwork were erection problems and the following notes on the erection may be of interest. The Author is indebted to Mr. A. Clark of Dorman Long and Co. Ltd. for assistance in compiling this information.

The contract involved the erection of 1,040 tons of structural steel, of which the heaviest piece was just over 4 tons. There were over 3,100 separate pieces to erect.

When formulating the method of erection, the following difficulties had to be considered :

(1) It was an island site with existing buildings in the S.E. corner.

(2) The east and north sides fronted on main roads with traffic lights controlling the intersection.

(3) The only access for materials was on the west side and this road was used by the United Bus Company's vehicles returning to the terminus for passengers, on approximately 50 per cent of the road services to and from Middlesbrough. This road could not be closed and offloading of steelwork had to be done in limited periods and at suitably slack times, i.e. early morning or late evening whenever possible.

(4) The stanchions rested on piled bases 15 ft. below pavement level and in some cases finished 100 ft. above pavement level.

(5) Steel erection was to be carried out in the first section of the contract whilst the excavation, piling and concreting of the finished basement were proceeding on the rest of the site.

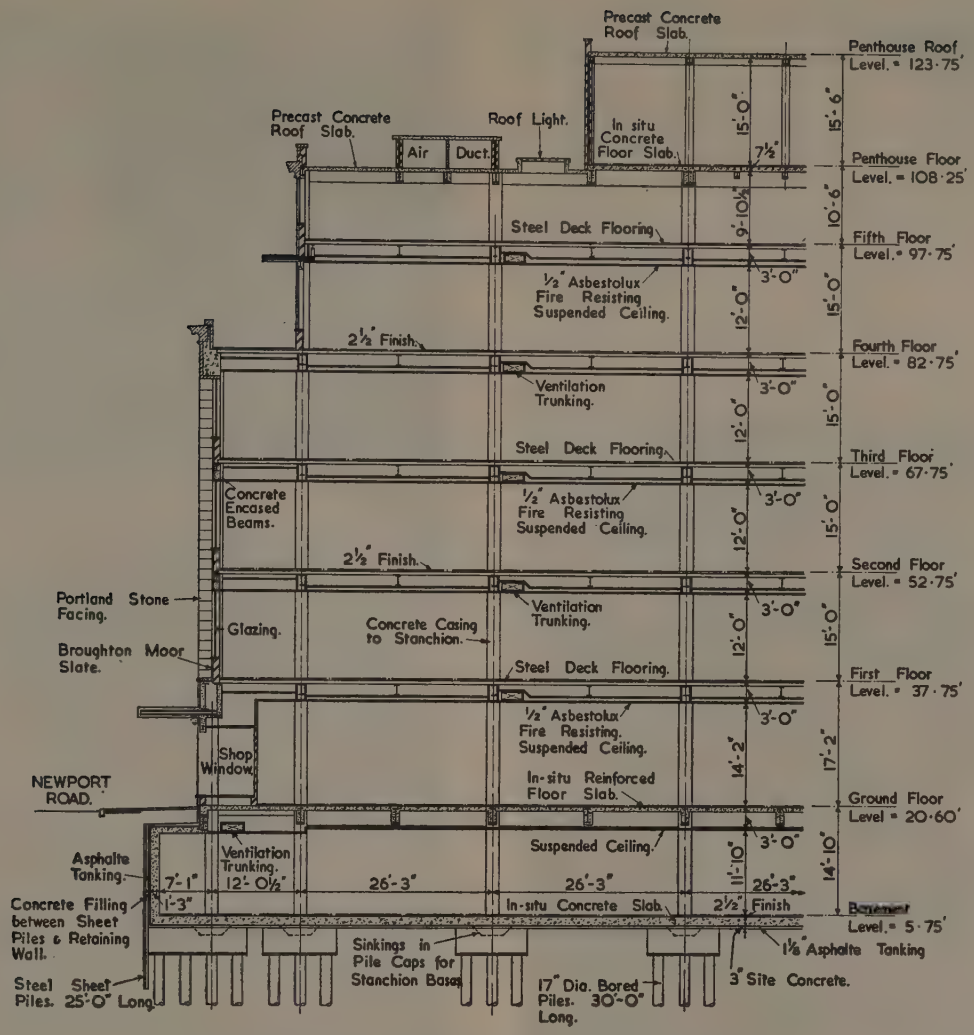
(6) Storage space for steel was extremely limited and as the basement floor incorporated a waterproof seal, great care had to be taken to avoid breaking this.

It was decided to use for the first part of the contract a 10 ton Scotch derrick with a 120 ft. jib operating from basement level. This derrick was erected on gabbards sitting on bogies which ran on flat bottom rails. The rails were carried in part on a gantry of 24 in. joists, suitably braced, and in part on a sleeper bed on the unexcavated soil in the basement. The raker legs ran west and north so that the derrick was unable to operate in the N.W. area of the site.

Care was taken to see that no load from the crane was put on the new concrete floor; and all load was carried partly on the pile caps and partly on the existing soil.

In this position 240 tons were erected, after which the crane moved back to its final position when a further 180 tons were erected completing Stage 1.

At this point a 5 ton Scotch derrick with a 100 ft. jib was brought to the site and erected on the top of



TYPICAL PART CROSS SECTION THROUGH STORE.

Fig. 7

the building by means of the 10 ton derrick. Fig. 8 shews the arrangement of the steel at about first floor level and also the 10 ton derrick through the steelwork. It also shews Stage 1 erection complete and the second derrick in position in the background. This second derrick was so placed that it stood on the four building stanchions Nos. 25, 26, 35 and 36.

These stanchions were suitably braced to form a square tower, and were kentledged with 100 tons of 6 in. × 6 in. steel blooms to resist any uplift. It was erected with its "blind" area to the south east part of the site, this being the portion occupied by the existing buildings; its radius of action effectively covered the entire building site.

In addition to erecting steel the 5 ton derrick was used for offloading other materials, and helped generally with the building operations such as excavating and concreting.

Both derricks erected a further 390 tons and then the 10 ton derrick was dismantled and loaded away by the 5 ton derrick which completed the steel erection. Some 50 tons of steel in various parts inaccessible to the cranes were erected by hand.

Whilst daylight permitted, overtime was worked to counterbalance the delays caused by offloading difficulties and lack of storage space. At no time were there more than 30 tons of steel in store on the site, but by careful ordering of steel, speedy offloading, and with the helpful co-operation of the police, there was very little inconvenience caused to the public.

Steel erection commenced 1st July, 1955, and was completed 24th February, 1956, i.e. in 34 weeks. Of this period there were nine weeks in which no steel was erected due to holiday periods, erection of roof crane and taking down of 10 ton crane, and three periods of absence from site whilst foundation works were progressing.

The maximum tonnage erected in one week was 80 tons and the average tonnage per week was 41½ tons.

Good weather was experienced for the first five months and although extra storm wires were fastened to the jib of the roof crane each night, it was only at the end of the year they were needed.

Fortunately, such accidents as occurred were of a very minor nature and were remarkably few in view of the height of the structure.

The cross section in Fig. 7 illustrates a number of features of interest. It shews the steel decking and it also shews the method of giving fire protection

to the structure ; a $\frac{1}{2}$ in. thick asbestolux false ceiling was used for this purpose and not only provides a light weight structure, but satisfactorily covers all the main services which are needed in a modern building of this kind. All heating and ventilation services are enclosed within the space above the false ceiling ; the electrical services are actually passed through the cells of the steel decking which form convenient conduits for the wiring. Provided that the number of fittings penetrating the asbestos ceiling do not aggregate more than 100 square inches per 100 square feet of the floor area, the asbestos ceiling is acceptable as a fire resisting medium.

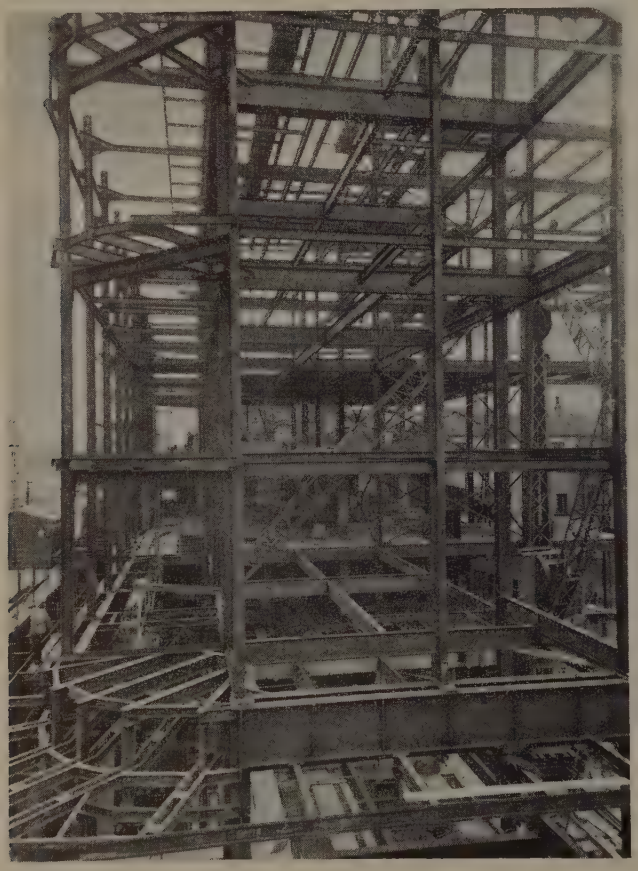


Fig. 8.

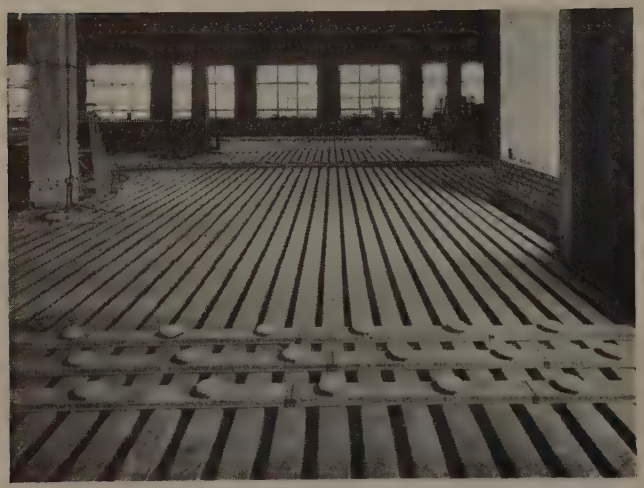


Fig. 9.

Fig. 10.

All the stanchions of the structure were encased in concrete up to above the level of the asbestos ceiling so that the structure complies with the fire requirements of the bye-laws.

Figs. 9 and 10 shew pictures of the steel decking and it is believed to be the first major structure in this country where such material has been used. The decking consists of gauge thickness steel sheet pressed to shape and weighing about 8 lbs. per square foot. The upper gauge is 14 and the lower 18 and the overall depth is $5\frac{1}{4}$ in. Concrete is filled into the gaps between the cells and for a depth of $2\frac{1}{2}$ in. over ; it may be either solid concrete or it may consist of a lower screed surmounted by a tile finish. The method of construction is widely used in the United States of America and is now finding acceptance in this country. One detail to which attention might be drawn is the provision of diagonal supports at all the columns. These are arranged in plan to form lodgements for the ends of the steel decking. In the present case they were also positioned in such a way that they would leave adequate gaps between the ends of the decking and the columns to allow pneumatic tubes to pass down the intervening gaps in the future should these be required in connection with the accounting system. The cells of the decking have been used to house the electric cables ; across the cells are arranged header ducts carrying the sub-main cables and having access points as required which come up to the floor surface. The whole arrangement is very flexible and economical.

Whilst the majority of the floors in the rectangular parts of the structure consisted of steel decking, the more complicated shapes in the Newport Crescent area made the use of anything but in-situ reinforced concrete very expensive. Accordingly, in-situ reinforced concrete was used combined with encasing to the steel beams and this had the added advantage of satisfactorily disposing of the twisting effects which arise from the curved external wall overhanging the straight steel framing. The roof generally was constructed in precast reinforced concrete units since a false ceiling was not desired on account of storey height. The steel beams were therefore encased and precast concrete units used for the roof construction. On the other hand, where a certain part of the roof forms the floor of the machinery penthouse, this part was constructed of in-situ reinforced concrete designed to spread the machinery loads as widely as possible over the structural steelwork.

The ground floor construction, however, was entirely different and consisted of in-situ reinforced concrete throughout. In addition, the slab was designed to carry debris loading from the superstructure and was physically tied by extended steel stirrups to the steel beams forming the ground floor construction. The floor is of heavy construction and is regarded as offering some protection to the basement space in the event of the superstructure being damaged.

All the staircases in the building are cast-in-situ reinforced concrete ; that to the basement could be satisfactorily shaped to suit the architectural requirements by reason of its being made monolithic with the reinforced concrete ground floor.

Fig. 11.

A feature of particular interest is the elliptical staircase which rises from ground to 5th floor in the back corner of the building. Fig. 11 shews the flight looking down from the 5th floor. This staircase is designed to have an aesthetic value and to attract customers ; it is not enclosed and does not form part of the escape facilities of the building. It is, in fact, a permanent showcase and accordingly was designed to have a particularly attractive appearance. On plan it is elliptical and is supported at each floor and once in-between ; the in-between support is obtained from the rear wall of the building which is suitably designed to carry the reaction from the intermediate landing of the staircase. On account of the number of stairs, however, two further landings at the quarter and three-quarter points are provided, but the staircase is not supported at these points. On account of the elliptical shape, the staircase was subjected to appreciable torsional forces which were aggravated to a considerable extent by the introduction of the intermediate landings. As a result the analysis of the staircase was complicated and assumptions had to be made as to the proportions of the torsional and normal bending forces occurring in the structure. As may be supposed, the soffite of the staircase is plastered throughout and in addition the staircase is finished in terrazzo. On these accounts it was necessary to ensure that any deflection was limited so that these finishings should not crack. For this reason arrangements were made to post-stress the structure and suitable tendons consisting of 4 wires 0.2 in. diameter with Gifford-Udall fittings were cast into the flights as they were constructed.

As the shuttering was removed from each flight, measurements were made of the deflection due to the dead weight of the structure. It was found that the inner edges of the quarter landings settled about $\frac{1}{8}$ in. and the outer edges about $\frac{1}{16}$ in. The half landing inner edge settled about $\frac{1}{16}$ in. and its support, of course, moved very little. After the staircase had been completed and all the shuttering and temporary supports had been removed a loading test was applied to the flight from 1st to 2nd floors amounting to 150 lbs. per square foot of stair, i.e. 50 per cent overload. The deflections under this loading were measured and it is satisfactory to record that all these deflections were small and nowhere exceeded $\frac{1}{8}$ in. The maximum deflection at the inner edge of the flight was $\frac{1}{8}$ in. and at the outer edge $\frac{3}{32}$ in. In these circumstances, whilst the post-stressing facilities have been left in the structure, it has not been thought necessary to make use of them and every confidence is felt in the reinforced concrete as it is to resist movement and therefore cracking of the finishings. It may be of interest to record that the length of the staircase on a normal flight is approximately 40 ft. from floor to floor and the root thickness of the stair nowhere

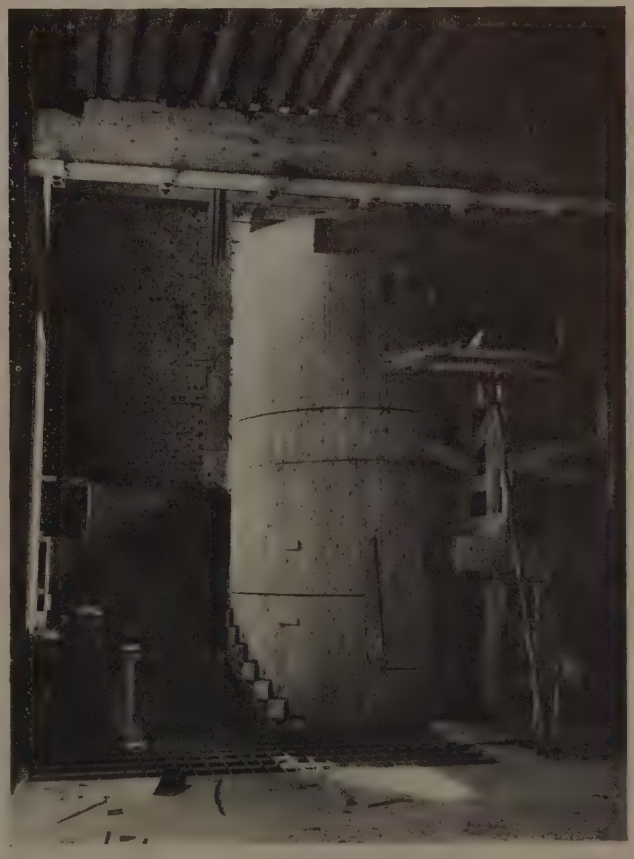


Fig. 12

exceeds 9 in. There is, of course, the intermediate support from the middle landing which has the effect of halving the span and the importance of this is considerable. At the time when the design was being prepared, a cardboard model was built in the office to discover the effect of introducing the intermediate support. The original desire had been to span from floor to floor, but the mathematical analysis indicated that a thickness of the order of 2 ft. would be required on account of the very large torsional forces involved. The introduction of the intermediate landing, therefore, had the effect of reducing this thickness so much that it was felt to be an essential provision and the effect of the intermediate landing was very markedly demonstrated in the cardboard model. Some reference to the method of building this staircase is appropriate. Fig. 12 shews that the shuttering was erected about a drum built up in timber and carefully placed in its true position. The drum was erected in the joiner's shop at Darlington and as may be seen it had the various steps and landings accurately set out on its surface. The shutters forming the risers were also accurately prepared so that the only essential work at site was the adaption of the basic form to each flight ; not that the work at site should be minimised in any way. Fig. 13 shews the arrangement from the landing of the 2nd floor. Attention may be drawn to the large amount of temporary timbering and scaffolding necessary below the flight under construction, and this is well shewn by the photograph. It may be of interest to record that the first flight took six weeks, shewing that the work on site was considerable, and the second flight required 5 weeks. As facility was gained in handling the drum

Fig 13.

and the other parts of the shuttering, the time per flight tended to become less, but this was counteracted by changes required to the drum itself as the flights changed in position. The concrete used in the staircase was a nominal 1:2:4 mixture. The reinforcement consisted of $\frac{5}{8}$ in. diameter bars at 3 in. centres top and bottom lengthwise and $\frac{3}{8}$ in. diameter bars at 6 in. centres transversely : typical details of the staircase structure are shewn in Fig. 14.

The structure as it has been briefly described represents the result of over $2\frac{1}{2}$ years of hard work. A

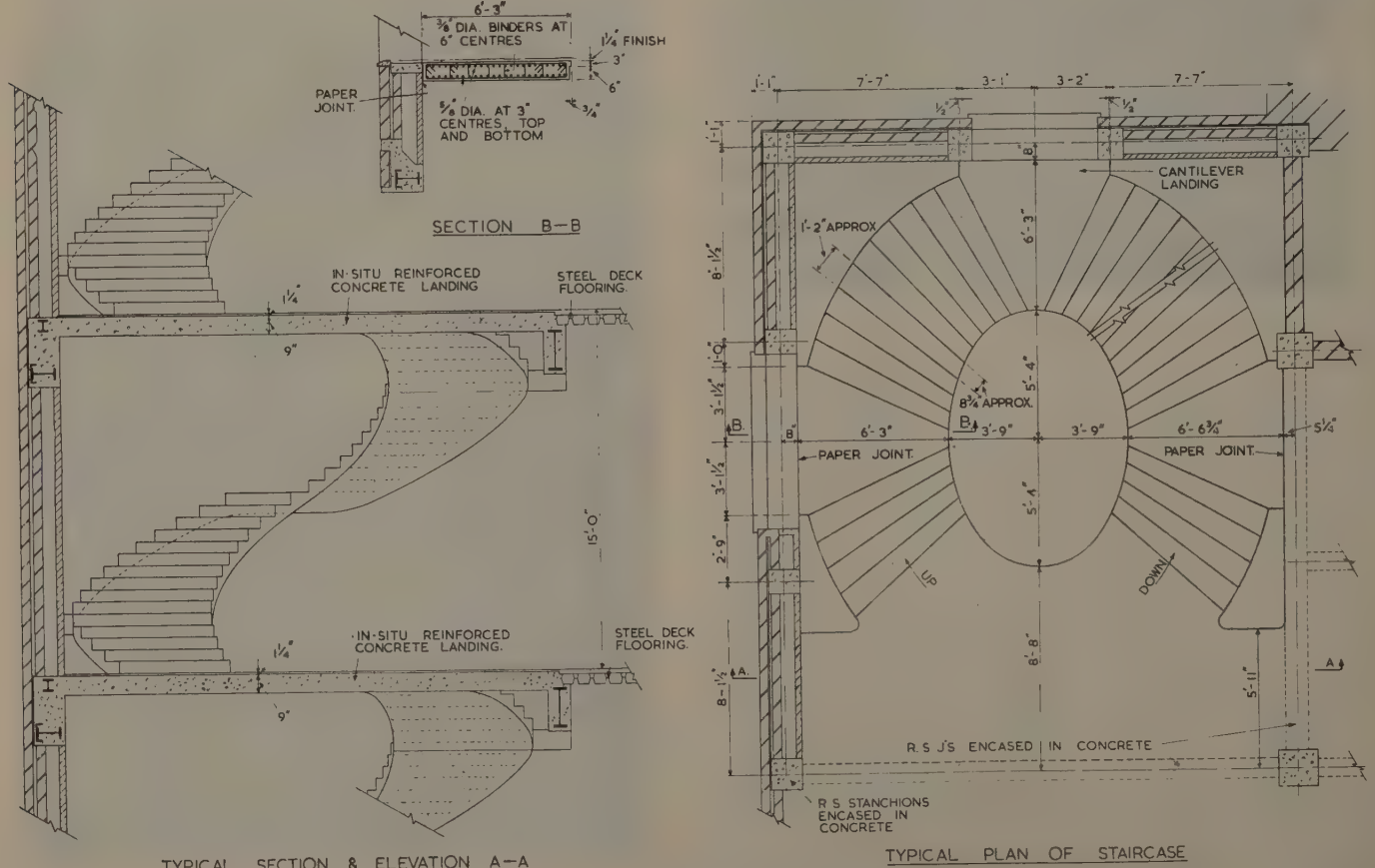


Fig. 14

modern departmental store makes provision for the sale of many articles and goods, and offers such a variety of facilities that engineering services of all kinds must be provided. Furthermore, adequate freedom must be given for all the electrical and mechanical services to be readily altered as the changing conditions require. Practically no reference has been made to the architectural features and the planning, to the electrical and mechanical services, to the shop fittings and the decorations. But the final result has only been achieved by the close collaboration of all the various specialists concerned working under the supervision of the Architects and directed by the Directors of the House of Fraser.

To Mr. A. Spence, the Director having the responsibility for the work and to the Architects Mr. Gordon Jeeves and Mr. Cecil Eve, the Author would pay tribute and express his personal appreciation of their never-failing courtesy and kindness. To the Contractors, Leslie & Co. Ltd. of London and Darlington, represented at the site by their agent Mr. F. Vosper, the thanks of all are due for their sustained co-operation and effort; and to all the many others associated with the work a word of appreciation is gladly given. The Consulting Engineers for the electrical and mechanical services were Messrs. Winton Thorpe, Tunnadine & Partners and for the structural works described in this paper, Messrs. F. R. Bullen and Partners.

Book Reviews

Reinforced Concrete Designer's Handbook, 5th Ed., by C. E. Reynolds. (London: Concrete Publications, 1957.) 343 + viii pp. 18s.

The fifth edition of this well-known handbook has been revised to incorporate the recommendations of the new "British Standard Code of Practice for Reinforced Concrete in Buildings," C.P. 114, issued in June, 1957. The tables and other information relate to the new stresses and other changes in the Code, and also to the load-factor (or ultimate load) method of design which is included in the Code for the first time.

As in previous editions, the volume has four parts, tables being grouped in Part II. Explanatory notes and other information form Part I, and Part III contains some examples of design which require reference to more than one table. Part IV deals with specifications and quantities. Improvements and additions have been made, in particular to those sections dealing with pressures of granular and cohesive materials, foundations, slabs supported on three or four sides and subjected to triangular load, loads on bridges, long columns, and the properties of reinforced concrete sections.

The Rent Act, 1957, by Robert Steel. (London: Royal Institution of Chartered Surveyors, 1957.) $8\frac{1}{2}$ in. × $5\frac{1}{2}$ in., 164 + xi pp. 15s.

The purpose of this book is to explain the Rent Act, 1957, which came into operation on the 6th July. The first two chapters deal generally with the scope of the Rent Acts in Great Britain and with the decontrols effected by the Act of 1957, chapters three and four dealing separately with England and Wales and with Scotland. The remainder of the book is concerned with furnished lettings, long tenancies, and miscellaneous provisions and covers.

Strength of Materials: A Text-Book for Degree Students, 2nd Ed., by G. H. Ryder. (London: Cleaver-Hume Press, 1957.) $8\frac{1}{2}$ in. × $5\frac{1}{2}$ in., 337 + x pp. 22s. 6d.

In this second edition of a text-book based on the syllabus of the University of London, extensive additions have been made to bring the volume up to date with new developments and keep it in line with the widening scope of the examination syllabus. Important additions are in the sections on material testing and experimental methods, on the effects of stress concentrations in members under tensile bending, on the elastic theory in the fields of strain analysis, with particular reference to resistance strain gauge practice, on torsion of thin-walled and cellular tubes and open sections, on beams on elastic foundations, and on strut analysis by the energy method. There is a new chapter on the plastic theory of bending, and sections are included on the plastic yielding of shafts and tubes under pressure.

The new edition contains additional and more varied illustrative examples and problems for the student, and further references have been included.

Holzbau-Taschenbuch, 5th Ed. Edited by R. von Halasz. (Berlin: Wm. Ernst, 1957.) $6\frac{3}{4}$ in. × $4\frac{3}{4}$ in., 428 + viii pp., illustrated. D.M. 19.50.

In the fifth edition of this handbook, the section on timber in river and harbour work has been omitted, but all other sections have been thoroughly revised and brought up to date.

Included in the handbook are sections on properties of timber, preservation, frameworks, joints, nailed and glued structures, timber bridges and houses, tools and machines for timber work, specifications, a bibliography and a list of German and Austrian Societies and Institutions.

The Relationship of the Architect and The Structural Engineer*

By Leslie A. Chackett, F.R.I.B.A., F.R.I.C.S.

Synopsis

THE paper outlines the status and conditions of engagement, and the codes of conduct, and refers to the scales of charges for the Architect, Structural Engineer and Consulting Engineer respectively. Consideration is given to the types of project on which the Architect requires the collaboration of an Engineer and to the various methods by which expert advice on structural matters can be obtained in respect of sites, foundations, framing, floors, cladding etc. Advantages and disadvantages of each method of collaboration are considered from the point of view of the client in respect of efficiency and economy, and suggestions made as to the many items upon which the Architect and Engineer, in collaboration with the Quantity Surveyor, can combine to give the best professional services to the client from the earliest stages of the project up to the certification of final accounts.

The idea of a paper on this subject emanated from the Literature Committee of the Institution of Structural Engineers who considered it was desirable to include in the series to be presented a paper with an architectural background. When the Author was approached on this matter the most obvious title for the paper seemed to be "The relationship of the Architect and the Structural Engineer."

It appeared to the Author that the subject offered considerable scope, not only as a basis for a factual and informative paper but to stimulate discussion on the various existing methods which are open to the Architect by which he may obtain the specialist advice he requires.

Opinion has always differed as to the extent to which co-operation between the Architect and Engineer is necessary. The paper deals with cases where interpretation of the clients' planning and aesthetic requirements necessitates the application of more advanced engineering experience than the Architect is trained to provide. The occasions for such collaboration are increasing; it is the methods and the extent of this collaboration which are examined in this paper.

In the first place it is useful to contrast briefly the professional status of the Architect and Engineer and their relationship to the client or Building Owner as well as to each other.

So far as the Architect is concerned conditions of engagement, scales of fees, code of conduct, etc. are well known and published by the various Professional Institutions which are Constituent Bodies of the Architects Registration Council of the United Kingdom.

This Council is constituted under the Architects Registration Acts of 1931 and 1938, and, as a corollary to maintaining a register of persons qualified to use the title "Architect," is responsible for disciplinary matters in the profession. These are dealt with either by the Discipline Committee or the Professional Purposes Committee.

In an explanatory appendix to the "Code of Professional Conduct" issued by the Architects Registration Council an example reads as follows:

"The employment of Consultants shall be at the Architect's discretion, in agreement with the client, and payment of their fees shall be a matter of agreement between the Architect and Client."

The Royal Institute of British Architects, by far the largest Constituent Body represented on the Architects Registration Council, publishes a booklet called "Conditions of Engagement and Scale of Professional Charges." Paragraph 8 of these "Conditions of Engagement" reads as follows:

"The employment of Consultants shall be at the Architect's discretion in agreement with the Client, and Consultants shall be nominated or approved by the Architect, and appointed and paid by the Client. Where it is agreed to retain the services of consultants in no case shall the Architect's fee be reduced by more than one-third on the cost of the work upon which the services of the Consultants are retained, provided always that the Architect's fee on the cost of the whole scheme shall not be reduced by more than one-sixth."

This whole question of remuneration is one upon which there are varying opinions. It is argued by some that the client should not be required to pay fees to both Architect and Consulting Engineer on certain parts of the work, although it cannot be said that the parts with which each is concerned are capable of definite separation.

We must also mention here the other case considered later in which no professional consultants are employed on a fee basis. Such cases may mean that architects' fees are based not only on actual cost of items such as structural steel, but in addition on what may be termed hidden fees for design. This is a point often considered too delicate for discussion.

Dealing with the Structural Engineers, many a Structural Engineer is of course employed by specialist firms and does not function in the same way as the Consulting Engineer as defined by the Association of Consulting Engineers. It is important to differentiate between these two types of Engineer with both of whom the Architect has associations, and this aspect is dealt with in more detail later in the paper.

The Association of Consulting Engineers, as some members of this Institution will appreciate, is not a Statutory Body similar to the Architects Registration Council, but comprises members of various professional Institutions. In its publications however it follows

* *Paper to be read before the Institution of Structural Engineers at* 11, *Upper Belgrave Street, London, S.W.*1., *on Thursday,* 28*th November,* 1957, *at* 6 *p.m.*

similar principles, in regard to professional conduct and remuneration, as the other professional Bodies. Among the publications issued by the Association of Consulting Engineers, reference is made to the problems of large modern buildings, some of which are " more correctly described as engineer structures with an architectural shell " and a note is included that " close collaboration between Architects and Engineers is, therefore, essential and in the public interest." In addition this Association publishes " Professional Rules and Scales of Fees " together with model forms of agreement. Of these forms, Model Form of Agreement C is " an agreement between a client and Consulting Engineer for the design and supervision of structural engineering work in buildings and other structures (where an Architect has been appointed by the client)." This document sets out very clearly the remuneration and duties of the Consulting Engineer, and forms a sound basis on which to work.

It is of course, as mentioned later, essential to define the extent of the duties and responsibilities of the Consulting Engineer, not only in respect of remuneration and fees, which are obviously necessary from the clients' point of view, but also for the information and benefit of the General Contractor and Sub-Contractors. Unless this is agreed in the early stages, responsibility for such matters as supervision, site instruction, and payment of accounts will be uncertain and the men on the job will not know to whom they may look for, and from whom they may accept, instructions.

Your own Institution publishes a Scale of Charges for consulting Structural Engineers, but while this envisages engagement direct by a client, it does not appear to make any reference to collaboration with the Architect.

For the purpose of this paper it is proposed to consider only the Structural Engineers as distinct from Civil Engineers and the other allied branches of engineering.

The Structural Engineers thus fall broadly into two categories :

(a) Those acting in a professional capacity in a similar way to the private practising Architect. These engineers will be referred to in this paper as Consulting Engineers.

(b) Those employed by commercial firms dealing in structural steel, reinforced concrete and specialist types of construction or those connected with reinforcement or other proprietary structural materials. Such engineers will be referred to as Structural Engineers.

It is not intended to refer to engineering works carried out entirely by the Consulting Engineer and which are of such a nature as not to require the services of or collaboration with an Architect, nor to those schemes in which the Architect functions as a design consultant only on some parts of a scheme.

In the normal way, for the type of scheme under consideration, it is the Architect who is commissioned by the client to advise on choice of site and prepare sketch designs and working drawings for a building project, and it is often obvious from the earliest stages that the employment of Consultants for various aspects of the work will be essential. It is then for the Architect to decide whether and if so what specialists will be required to deal with or advise on such items as :

(a) Site exploration and survey.

(b) Foundations, piling, etc.

(c) Steel or reinforced concrete framing.

(d) Superstructure, floors, roofs, etc.

The Architect therefore has to consider the basis upon which the necessary Consultants should be employed. There are three methods in common practice which for convenience may be listed as follows :

1. Engagement of a professional Consulting Engineer.
2. Employment of commercial firms direct as Structural Engineers on the various aspects of the scheme.
3. Engagement of a Consulting Engineer as adviser on schemes submitted by commercial firms.

On jobs of any size or complexity, one or other of these alternatives seems essential under present day conditions, since Architects at the present time have neither the time or ability to try to function as did their predecessors in the past as Engineers and Quantity Surveyors in addition to being Architects. This fact is of course clearly recognised in the Architect's training by the omission of any advanced teaching in these subjects.

On the type of scheme envisaged, the client will obviously be interested in the financial implications of the various methods of collaboration, and the Architect will have to make his recommendations as to the most suitable arrangement having regard to the project under consideration.

In making such recommendations the Architect must consider his own professional responsibilities to his client. It is outside the scope of this paper to deal in detail with this particular aspect, but it must be appreciated that the amount of actual work by the Architect will vary in each case.

If a professional Consulting Engineer is appointed either in a design capacity (Method 1) or in a consultative capacity (Method 3), a proper basis for remuneration in accordance with scales of professional charges can be agreed in the early stages of the work, and the spheres of responsibility can be defined.

Alternatively, if commercial firms are employed direct (Method 2) neither the architect or the client will normally be aware of the sums allowed in the various schemes for design, preparation of drawings, submission of calculations and other technical advice. In addition it will be more difficult to define the extent of responsibilities. The Architect may also have much more work in co-ordinating the schemes produced by the respective specialists. He will have to prepare composite drawings and possibly rely on specialists to provide him with requisite drawings and calculations to meet requirements of Authorities for approval under By-laws and other Legislation.

There is another very important aspect concerned with tendering. If a professional Consulting Engineer is appointed, competitive estimates can be obtained for each of the various sections of the work based on drawings and specifications prepared by the Engineer in collaboration with the Architect.

If commercial firms are employed direct, tenders will not normally be comparative, because designs are unlikely to be on a common basis and, in addition to costs of labour and materials, the figures submitted will also allow for costs of design in the firm's drawing office. While it is not unknown for schemes to be prepared by specialist firms and then to be adapted and used as a basis for competitive tendering, this

is hardly a fair and reasonable method of procedure.

Most specialist firms necessarily have a somewhat restricted outlook. Their technical staffs would obviously be exceeding their brief if they started advocating designs of a different nature to the particular type which their employers were in business to promote.

For example, a firm manufacturing rod reinforcements might not advocate the use of mesh reinforcement in a case in which the labour involved with mesh reinforcement might be substantially less.

In addition, one cannot expect undue collaboration between specialists even when dealing with related matters. As an example of this, may be quoted the fact that whereas steel work firms will normally give stanchion loadings, they disassociate themselves from any question of the design of the foundations. Such matters then fall to be co-ordinated by the Architect.

It is of course frequently argued by the specialist firm that because of their wide experience in a particular sphere they can effect economies in materials without loss of strength. The Engineer, on the other hand, replies that a scheme from a professional office is impartial as to the use of any particular materials. This impartiality can be of direct value as it cannot be denied that some specialist firms tend to be " heavy handed " with the particular materials they are anxious to sell.

If a Consulting Engineer is engaged as Adviser instead of Designer (Method 3) this is of course a compromise between the other two methods. The Architect can rely on advice from his Consulting Engineer as to the suitability of various alternative schemes, and the Consulting Engineer can co-ordinate the work of the respective specialists. Although the point previously referred to regarding the charges for technical advice and design remains obscure, the Consulting Engineer can from his professional experience advise the Architect whether rates upon which estimates are based are fair and reasonable.

In this connection clients do not normally appreciate the point that specialist commercial firms cannot afford to maintain salaried Engineers, Designers and Drawing Office Staff to prepare schemes without increasing some of their tender rates above the figure they would allow when submitting a tender based on designs and specifications prepared by a Consulting Engineer.

In accepting Tenders under any of these methods it must not be forgotten that present conditions are abnormal and that delivery dates and standard of service offered are often the deciding factors in the appointment of a particular sub-contractor, especially when the prices are very close together.

This is particularly true at the present time in the case of structural steel and reinforcement. The maintenance of a system of competitive pricing is of considerable importance to the client, but this aspect must be outside the scope of this paper.

It would therefore seem, both from an academic and professional point of view, that the most satisfactory basis wherever possible on the type of scheme under consideration is that the Architect should obtain his client's authority for the appointment of a Consulting Engineer in his full professional capacity as early as possible in the design stage of the project.

When the Architect has obtained the general details of the clients' requirements and has sorted these out, often in the form of a rough sketch scheme, client and Architect can then meet the Engineer to discuss the structural aspect of the clients' requirements. While structural considerations may cause considerable modifications from the original sketches, these have not been wasted since such preliminary analysis enables the Engineer to see the problems involved more readily. It is at this stage equally desirable for the Architect to obtain approval from the client to the appointment of a Quantity Surveyor. It is almost always essential for the client not only to know at an early stage what type of building the Architect considers to be most suitable for the purpose in mind, but also to know whether the scheme is sound from an economic as well as structural point of view. Early appointment of the Quantity Surveyor thus enables the client to know the approximate cost and possibly the comparative costs of various alternatives. Co-operation, therefore, between Architect, Consulting Engineer and Quantity Surveyor is invaluable from the earliest stages. The Engineer will be able to advise from his own experience on the economies of various types of structure and the Quantity Surveyor will be able to analyse more detailed costings for comparison and give overall figures for alternative methods of construction. Clients appreciate the fact that they are obtaining the benefit of professional advice from three experts each dealing with various aspects, and joint meetings or discussion assist enormously in evolving a solution likely to prove most satisfactory from every point of view.

It must not be forgotten, however, that Building Legislation is making more onerous the early co-operation of Architect and Engineer. While it is possible to obtain from Local Authorities a general idea of their requirements for a particular site, they will not commit themselves in any detail until a concrete proposal has been submitted to them. It is at this stage that a joint conception by Architect and Engineer may suffer drastic modifications as a result of the more definite thoughts which the Town Planning authorities give to a particular site when an actual scheme is presented to them.

It is not unknown for a scheme to have to be revised to such an extent as to bear no relationship to the original; and such revision will of course necessitate a considerable amount of additional work and consultation between Architect and Engineer and Client.

At the risk of stressing the obvious, it seems helpful to summarise the main headings on which collaboration between the Architect and Consulting Engineer is necessary.

1. *Site.*

Advice on choice of site will be helpful if alternatives are available. When the site is settled the advice of the Engineer as to the type of site investigation required is invaluable. This will include recommendations on such matters as trial holes, borings, soil tests, chemical analysis of sub-soil water, and possibly advice on special cements and other materials to suit unusual conditions.

2. *Foundations.*

As a result of site investigations, the Engineer will then be able to advise the Architect on the most appropriate method of carrying the particular building required. This may involve piling, block foundations, raft or other special forms of construction, and the Engineer can collaborate on problems of underpinning

and waterproofing. Advice may also be required on structural problems affecting adjoining buildings.

3. *Frame.*

The Engineer will be able to suggest the type of frame most suitable for the project, either in steel or reinforced concrete, with advice as to the economic spans, spacing of columns etc., having regard to such points as the use to be made of the building, loading on floors, plant requirements, problems of site access on restricted sites, and the relative effects on speed of erection of various structural forms.

4. *Floors and Roof.*

A wide choice of materials for floors and roof is open to the Architect, and the Engineer will be able to advise on the merits of hollow, solid, precast or other forms, bearing in mind economic spans, type of loads to be carried and finishes required.

5. *Working Drawings.*

During the evolution of a scheme for foundations and a structural frame, the advice of the Engineer may be sought on the cladding of the structure, particularly in relation to support of wall panels etc. on the frame, construction of window openings, shapes and sizes of stanchions and beams. The Architect will normally have produced preliminary $\frac{1}{8}$ in. scale drawings embodying structural methods considered most suitable for the particular problem in mind, but it is when the final $\frac{1}{8}$ in. scale drawings are under preparation that collaboration with the Engineer becomes essential on any complex job. Framing plans can then be prepared by the Engineer which will indicate sizes of stanchions and beams and also settle, by schedule, the method of reference for stanchions and beams. As the scheme develops the appreciation by the Architect of the engineering problems and by the Engineer of the architectural design envisaged is even more important. Draft $\frac{1}{2}$ in. details and full size drawings will have to be considered, and in many cases these will have to be approved by the Engineer so as to ensure that fabrication details, beam sizes, casings, etc. are adequate. The $\frac{1}{8}$ in. scale working drawings upon which the General Contractors, as well as the steelwork and other specialists will rely can then be completed. These should include stanchions references, together with any other information necessary to enable them to be read in conjunction with the Engineer's framing plans.

6. *Specifications and Estimates.*

When stages 1—5 have been completed the Engineer will be able to prepare specification, framing and detailed drawings for the various structural sub-contractors. At this stage it is important to consider the conditions of tender and terms of contract upon which certain specialist firms normally quote in relation to the provisions of the R.I.B.A. standard Form of Contract. It must be realised that the Building Owner will normally have a contract with the main contractor on a standard R.I.B.A. Form, and it is for the Engineer to advise the Architect on any points where sub-contracts need modification to be brought into line with the general conditions.

Items such as discounts to the General Contractor, time and method of payment etc. need to be settled. Payments to sub-contractors are dealt with in the main contract and the form of sub-contract must be on the same basis unless either the general contractor or the Building Owner are prepared to make exception for certain specialists who may wish to abide by special trading conditions. It is in any case the duty of the Architect when issuing certificates to notify the General Contractor of sums included as payments to Sub-contractors and it is most desirable that the Architect should also advise the Sub-contractors of gross amounts included so that they can check up payments made.

7. *Services.*

Heating, electrical work, plumbing and drainage call for consideration quite early in the preparation of working drawings and it is essential that the Engineer should be aware of intended pipe runs etc. so that they can be allowed for wherever possible in the design of the structure, or alternatively positioned in such a way that they do not cause any complications with foundations, reinforcement etc.

8. *Quantities.*

At the stage when quantities are being prepared, collaboration between the Consulting Engineer and the Quantity Surveyor becomes essential in order that proper provisions may be made in the Bill of Quantities for estimates from specialist sub-contractors. Quantities dealing with reinforced concrete work, etc., will be measured from the Engineer's details and his requirements as to materials, workmanship and method of construction must be properly incorporated in the Bill.

It is important to agree on the extent and in due course the cost of the work upon which Engineers fees are calculated. This information will be supplied by the Quantity Surveyor and if considered at an early stage can sometimes be simplified by sub-division and itemising certain parts of the Bill of Quantities and grouping the relevant P.C.s and Provisional Sums. These items can then be identified in the final account. This is an aspect often overlooked by the Quantity Surveyor.

9. *Execution of the work.*

In the early stages of the job supervision of the engineering works will be more in the hands of the Engineer than the Architect, and as the job progresses the Engineer can assist appreciably in certifying accounts and in due course advising on any claims made by the sub-contractors in respect of variations of works in which the Engineer had the prime interest.

In connection with the accounts for work done by Steelwork Contractors there is a strong feeling in the trade that the period of retention should be related to completion of the sub-contract works rather than to completion of the whole of the work covered by the main contract. This is a point for consideration, particularly in large buildings where the steel frame is completed a long time before the building is ready for occupation and before normal maintenance periods commence.

Suggestions have been made in this paper as to the method of collaboration likely to be most successful. It is however, not easy to generalise and each project must be considered on its own merits. A large straightforward office block with a regular steel or reinforced concrete frame could, for instance, be built on a normal site by a General Contractor, under the supervision of an Architect working in collaboration with a specialist

firm, acting as consultant designers as well as Sub-Contractors for the structural frame. If, however, a similar type of building was contemplated on a site where complicated foundations with piling, water-proofing treatment etc. were necessary, a compromise might then be appropriate whereby a professional consulting engineer was employed for foundations as distinct from the super-structure.

Other problems which might well necessitate the employment of a professional Consulting Engineer would be such items as irregular building sites calling for complicated stanchion lay-out, heavy loading resulting from machinery or other equipment, together with any special requirements which would involve the collaboration of more than one specialised commercial firm.

The extent to which any particular project is subject to control by local authority under bye-laws is also a matter which may affect the method of collaboration adopted. For example, it is generally accepted that the control of building in London under the London Building Acts is much more strict than in the provinces. Not only are Building Acts themselves more stringent in their requirements, but detailed calculations etc. have to be approved by the District Surveyor, who is himself a competent engineer. Careful supervision is carried out by the District Surveyor or his staff throughout the construction of the building, and he will probably wish to discuss technical points with someone competent to deal with them.

It is sometimes argued that the English method, whereby Architects, Engineers and Quantity Surveyors function under their professional code of practice and then invite tenders from building contractors, is less efficient from the clients point of view than the methods adopted in certain countries abroad. It is quite common in many countries for the client who wishes to erect a building to be able to obtain competitive schemes prepared by a team comprising Architect, Engineer, specialised Consultants and Contractors, and to enter into contract for the complete services involved in the project from the start to finish, either at a lump sum or some other form of contract.

This is a problem which is receiving a lot of consideration from the various professional bodies at the present time, but it seems rather outside the scope of this paper to consider it in detail. One of the main points to be borne in mind in connection with these so called " all in " tenders is the fact that the Architect or Engineer involved is usually a salaried employee of the contracting firm. As such, he owes allegiance to his employer and cannot exercise his professional skill directly on behalf of the Building Owner. The only compromise which has been employed, but is not always possible, is for the Building Owner to agree on the extent of the professional advice allowed for by the " Contracting Group " and by agreement to employ his own professional advisers—Architects and/or Engineer on a fee basis with an agreed sphere of responsibility to watch the Building Owner's interests.

There is another problem which frequently arises in the early stages of a project, where the Building Owner may be in some difficulty as to whether to consult first with an Engineer rather than an Architect.

There are of course many instances where a Building Owner is prepared to accept advice either from the Engineer if he recommends collaboration with the Architect, or conversely if the Architect recommends that the services of an Engineer are essential. In such cases the project can proceed on what may be regarded as the idealistic lines referred to earlier in this paper.

There are, however, other cases in which the Building Owner is reluctant to commit himself to professional fees for two advisers, and in the early stages it sometimes happens that the particular consultant approached is obliged to proceed further than he would wish in the preparation of schemes without the benefit of other professional advice. Such cases have each to be dealt with on their own merits.

This paper deals with the subject on the basis that the Architect assumes the role of leader of a team of experts. His position must be agreed from the earliest stages to avoid any complications in the translation of the Building Owner's requirements into the form of the actual building and during the execution of the work. Early agreement is equally essential in cases where an Engineer assumes control of the team and the Architect functions in the position of a design consultant.

It is in an attempt to solve this problem of control and responsibility that there are, as mentioned before, arrangements in certain countries whereby the Building Owner can obtain a composite scheme without appointing specific professional consultants. In this country however, the professional system has grown up over many years and still seems to be a method of building which has produced and can continue to produce most satisfactory results.

It must, however, be realised that the whole building industry has during the last hundred years undergone very considerable changes, not only in regard to the design of buildings but more particularly into methods of construction and materials employed. Even within the last thirty years or so, remarkable developments have taken place in the use of specialised forms of construction and materials with some of which neither the average Architect nor Engineer is sufficiently familiar to use without the collaboration of specialised manufacturers and erectors.

There is therefore undoubtedly a new aspect to be considered where the specialised contractor assumes a far more important role in the building team, by virtue of his specialised knowledge and experience, than he would have done when the range of materials and methods of construction were not only more limited, but were matters with which the average Architect or Engineer was fully conversant.

It is not the intention of the writer to try and advocate any standard form of procedure. It is necessary in all cases calling for collaboration between the Architect and the Engineer that the relationship should be framed in the manner best calculated to meet the particular requirements of the Building Owner with regard to the circumstances of the particular case.

Certain main items upon which such collaboration is desirable have been set out. Reference has been made to various alternatives. Advantages and disadvantages of each have been discussed, but there may well be other relevant facets to which no reference has been made. Perhaps therefore, if the sins of commission do not provide a basis for a useful and constructive discussion, the sins of omission will do so,

Universal Beams and their Application*

By S. Barlow, M.I.Struct.E., and G. Foster, A.M.I.Mech.E.

STRUCTURAL Engineering throughout the world is influenced almost as much by the quality and efficiency of the rolled steel sections available to the engineer as by the price of steel relative to the cost of other construction materials and labour.

In Britain, the Structural Engineer has for many years had the benefit of constructional steel of the highest quality at a reasonable price. Steel supplies have, however, been generally confined to the British Standard sections listed in most structural steel manufacturers' handbooks. Whilst these may be a reasonable range of shapes and sizes, the shapes generally are not as efficient as they might be, nor is the range of sizes nearly as wide and comprehensive as it could be. For instance, structural designers, who prepare designs in competition with countries having a good range of broad flange beams, know something of the advantages these have for certain duties over the normal British Standard beam sections and of the economy of weight and workmanship that such broad flange beams can secure.

In these days of intense competition from other methods of construction it is of national importance that the British Constructional Engineer should be highly competitive in world markets. It is clearly not good enough to rely on the existing range of structural shapes and sizes which can only be classed as reasonable. The position to-day more than ever demands maximum efficiency and highest productivity in all engineering effort. The approaching completion by Dorman Long of a new rolling mill in the North East of England designed specifically for the purpose of rolling a new and wide range of efficient beam and column sections is therefore a matter of great importance. Its impact on all Structural Engineers and other users of beam and joist shapes will be considerable.

The mill, which is being installed at the new Lackenby Steelworks, is a Universal Beam Mill which will roll a comprehensive range of efficient beam sizes to be known as Universal Beams. The largest will be 36 in. deep with 16½ in. wide flanges and the smallest 6 in. deep with 6 in. wide flanges. The mill will also be capable of rolling any of the present range of British Standard sections, but it is expected that the more efficient Universal Beams will quickly supersede the British Standard joists in the medium and heavy range. It is therefore probable that, in addition to the new Universal Beams, only angles, channels and piling will be rolled in the new mill.

The production of Universal Beams will represent the climax of a great scheme of iron and steelworks development undertaken since the war. In carrying through this scheme, over £60 million will have been spent. The Universal Beam Mill itself is costing £18 million. Steel for beam production will be supplied from the Lackenby Steelplant which was completed in 1953 at a cost of £8¼ million.

* *Paper read before the Institution of Structural Engineers at Church House, Westminster, S.W.1, on Thursday, 31st October, 1957. Professor Sir Alfred Pugsley, O.B.E., D.Sc.(Eng.), F.R.S., M.I.Struct.E., M.I.C.E., F.R.Ae.S. (President) in the Chair.*

The new Universal Beams will fundamentally be rolled by the same process as was first developed on the Continent by Henry Grey. This process is also now widely used, with modifications and improvements, in the United States of America. There have, however, been great advances in mill engineering and practice since the last new full range beam rolling mill was installed in the U.S.A. in 1930. In consequence, a great deal of research, planning and design has gone into the new Universal Beam Mill which embodies many new and unique features as well as the development of old, well-proved rolling techniques.

The needs of Structural Engineers have been carefully reviewed and much thought has been given to the selection of the range and number of individual sizes to be rolled. A range has been chosen which is fully adequate without too many sizes being included. If many more sizes had been included, the interval between rolling of each size would be unduly lengthened.

Many expected as well as unforeseen difficulties will undoubtedly have to be overcome before a project of this size, complexity and advanced design is brought to the stage of successful production. It is hoped, however, to begin experimental rolling early in 1958, and no effort will be spared to achieve effective production in the shortest possible time.

Beam Rolling Technique.

Towards the end of the nineteenth century attempts were made to roll beam sections larger in size, especially in flange width, and with less flange taper than could be rolled in the two-high conventional rolling mill, equipped with horizontal rolls only. Experiments centred around a roll stand with two vertical and two horizontal rolls mounted in the same vertical plane. Although many experiments were made, no solution to the difficult rolling and engineering problems involved was found until an Englishman, Henry Grey, successfully developed beam rolling in a four-roll mill at Differdange, Luxembourg. This mill, laid down in 1902, was the first commercially successful plant and was capable of producing beam sections up to 1 metre (39.37 in.) deep and with a flange width of 300 mm. (11.8 in.) and taper of 4½°. The mill, rebuilt in 1912 and again in 1930, to-day produces the full range of sections listed in the German Standard list, ranging from 100 mm. × 100 mm. to 1,000 mm. × 300 mm., all with near parallel flanges.

Since this first successful mill was established, further beam mills have been built, one at Illsede-Hutte, Peine, Germany, and five in America—three by the Bethlehem Steel Company and two by the United States Steel Corporation—making a total of seven beam mills in existence at the present time. Recently Inland Steel Company have carried through a major reconstruction of their existing heavy section mill in order to be able to produce beams up to 24 in. deep.

Beam and column sections are also rolled with near parallel flanges on modified two-high reversing mills on the Continent, and more recently, in one mill in the United Kingdom. Such modified mills produce

a joist in conventional roll passes and remove the rolling taper in a single four-roll or universal pass They do surprisingly good work, but are less flexible than true four roll beam mills. They are limited in the width of flange produced and in the number of different flange thicknesses which are possible without excessive roll changing.

The mill at Lackenby applies modern mill engineering to the four-roll technique and will be the first of its kind in this country and the most advanced of this type in the world. It will be capable of producing a very wide range of beams and columns and each will be produced with a range of flange and web thicknesses giving much narrower modulus steps than have hitherto been available in the United Kingdom.

They will give very wide coverage of modulus requirements which can be considered as almost universal. They will be rolled in mill stands mounting four rolls in the same vertical plane—an arrangement known for many years as a universal mill. The term "Universal Beams" is therefore singularly appropriate.

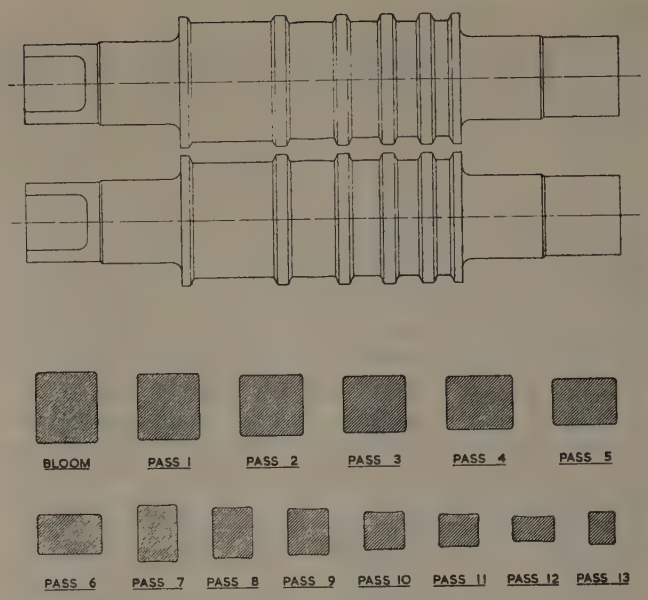


Fig. 1.—Stages of Bloom Reduction

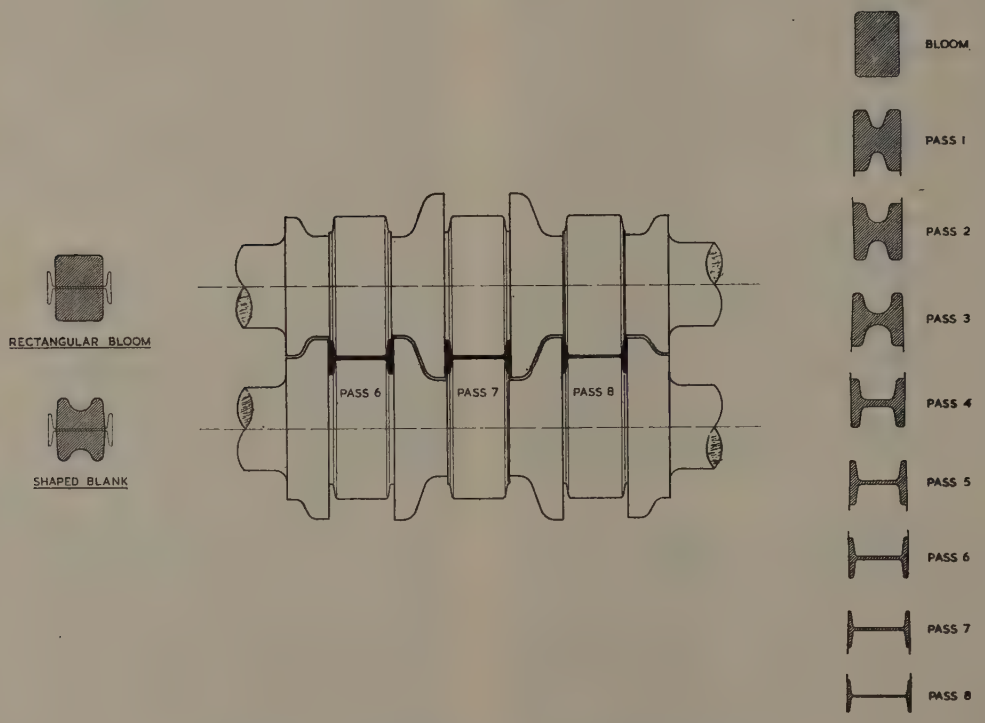


Fig. 2.—Finishing Stages of Beam Rolling

Steel arrives at the larger rolling mills in the form of steel ingots usually rectangular, weighing from 4 to 20 tons, and from 400 to 2,400 sq. ins. in area. All large rolling mills have a primary mill for the purpose of reducing the cross sectional area of these ingots to make the required shape for the finishing mills.

These shapes, or blooms as they are called in this country, are made by rolling the ingot back and forth between two suitably grooved rolls. The space between the two rolls is reduced between each pass and the stock being rolled is turned a number of times during the process to present each face of the ingot to the roll. This operation densifies the grain structure of the steel and vastly improves its physical properties.

The British Standard joist is usually rolled from a rectangular bloom in several passes through separate shaped grooves in two-high or three-high mills. In each pass the two rolls compress the steel in an almost closed groove longitudinally as well as against the side walls of the groove. Fig. 1 shows in diagrammatic form the stages of bloom reduction. Fig. 2 is a diagrammatic illustration showing the finishing stages of beam rolling in a two-high mill.

The process requires plenty of flange taper to avoid the flanges sticking in their closed grooves. The peripheral velocity of the different parts of the groove in contact with the flanges of the beam being rolled varies with the distance from the axis of the roll. The wider the flange the more unequal are these velocities. The flanges are reduced in thickness by compressing the hot steel between almost vertical faces in the groove and do not, therefore, receive proper rolling pressure.

Such limitations in a two-high mill make it very difficult to arrange sufficient flange elongation to balance the much more easily applied elongation of the web. Beam forming grooves formed of two rolls, therefore, conform only imperfectly to the basic requirement for rolling beams free from rolling stresses, i.e., the uniform and simultaneous elongation of all parts of the section.

In contrast the universal beam rolled in passes between four rolls is shaped by direct rolling pressure and the faults of indirect shaping are substantially avoided. Fig. 3 is a diagrammatic illustration showing the roll arrangement for beam rolling in the Universal Mill and Fig. 3a stages in Universal Beam rolling.

The universal mill rolling unit consists of a four-roll or main stand, with a two-high supplementary stand in line with and as close to the main stand as possible. Horizontal and vertical rolls are adjusted between passes and reduction in the thickness of both web and flange takes place in the main stand. The supplementary stand has two rolls only and works the edges of the flanges, squaring up and controlling their length.

In the main stand the setting of the vertical and horizontal rolls for each separate pass is arranged so

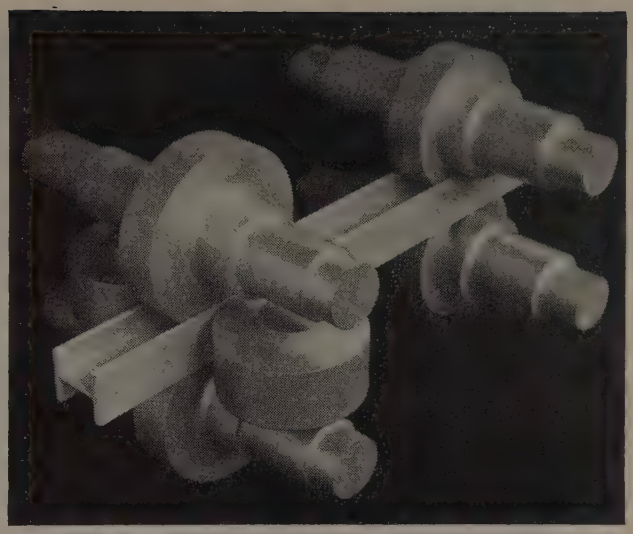


Fig. 3.—Roll Arrangement in Universal Mill (Photograph Model)

that the elongation of the web and the flange is controlled with precision, ensuring that all parts of the section being rolled elongate equally, thus avoiding rolling stresses. There are no closed passes to cause difficulties due to the flanges sticking in the rolls and the flange taper can, therefore, be very small. The production of beams with very wide flanges, with little or no flange taper and very thin webs is, therefore, possible in such a mill.

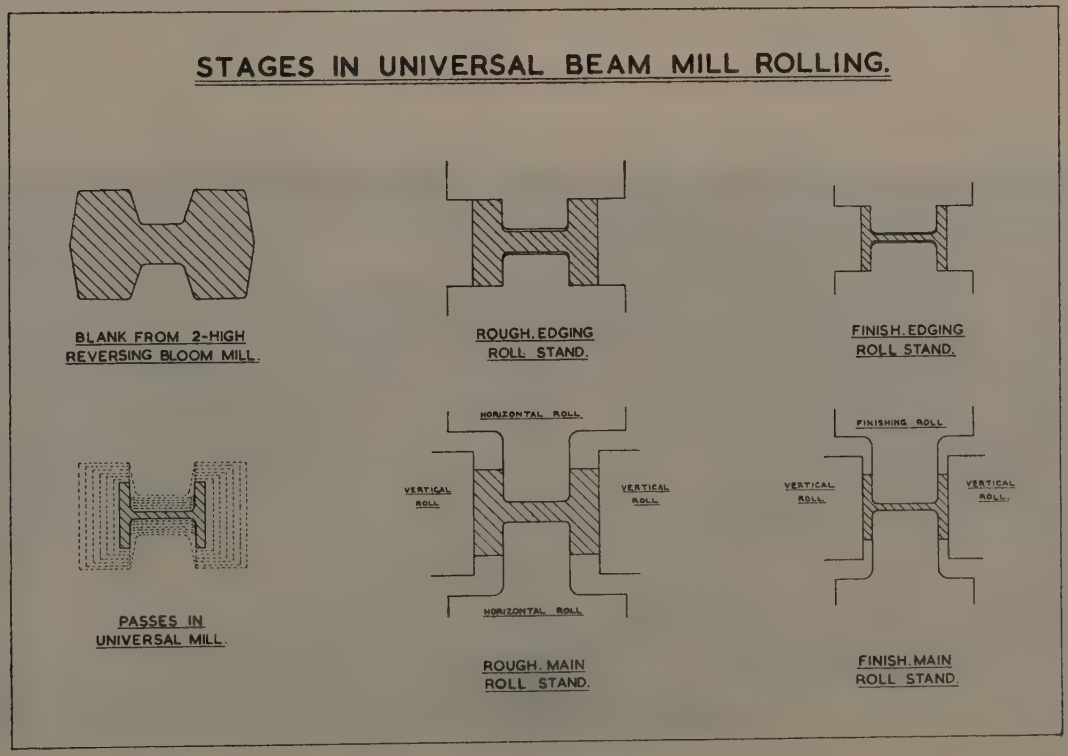


Fig. 3a.—Stages in Universal Beam Mill Rolling

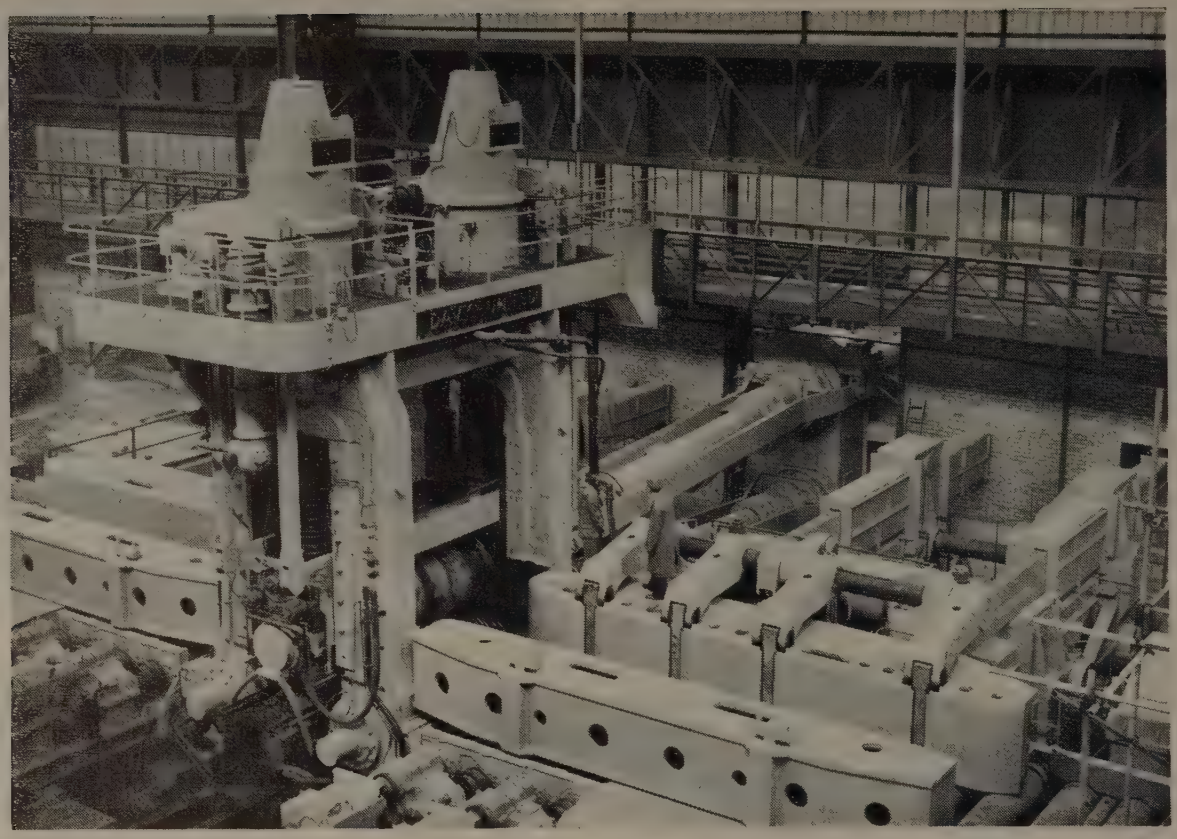


Fig. 4.—Modern Blooming Mill

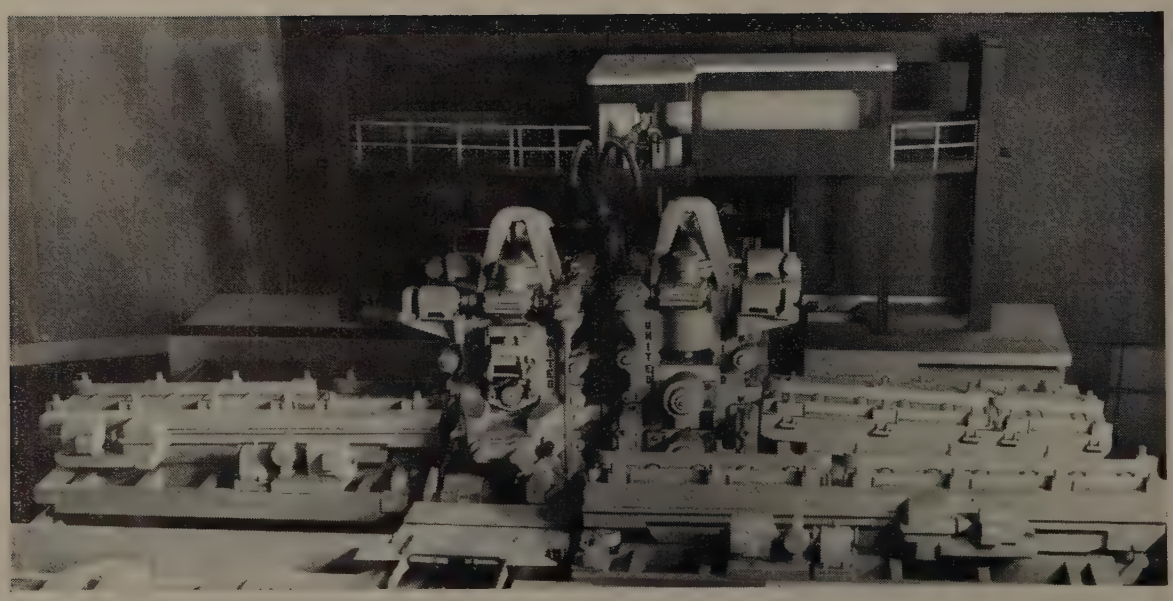


Fig. 5.—Universal Roughing Stands

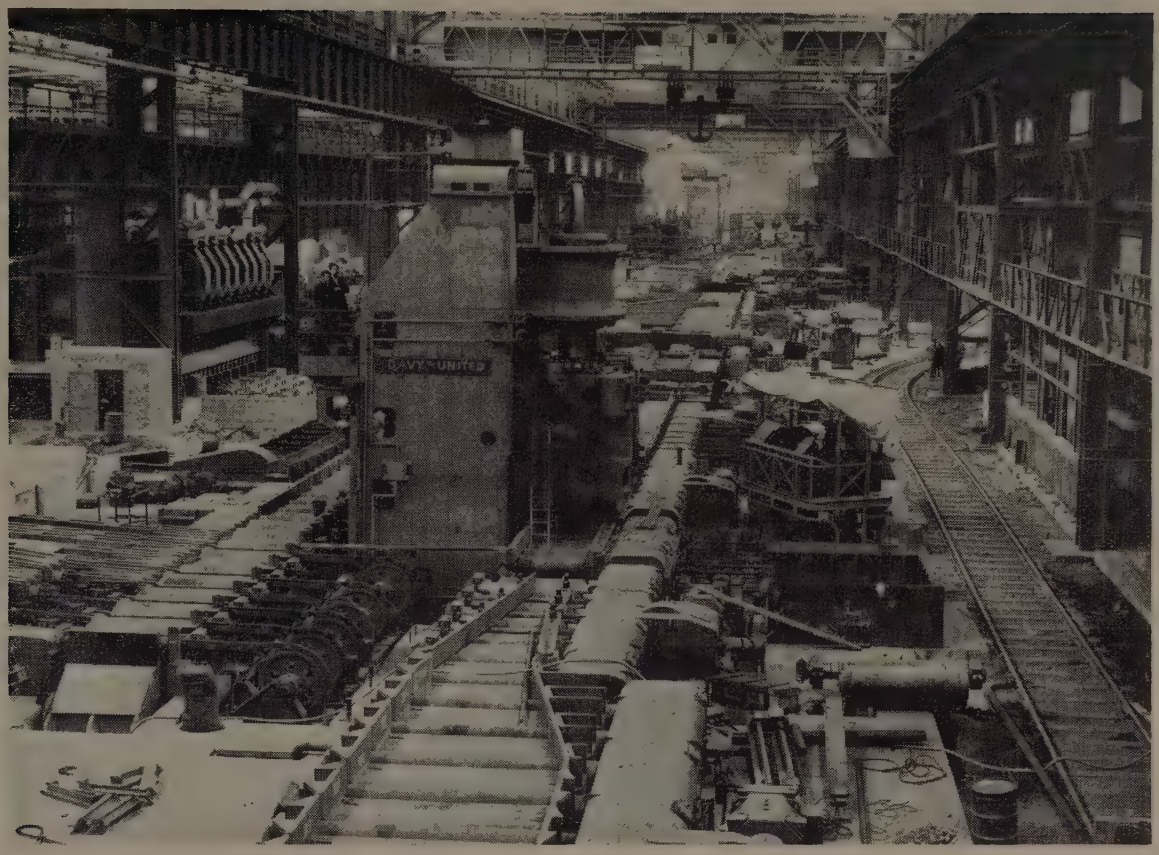


Fig. 6.—General View of Interior of Mill Building during Construction

Figs. 4, 5 and 6. The new mill comprises a Blooming Mill with rolls 50 in. dia., the working faces of which are 112 in. long, followed by universal roughing and finishing units having rolls up to 53 in. dia. The two latter units have independently driven supplementary roll stands controlling the flange length of the beam. Initial shaping in the blooming mill will produce an H shaped bloom with a web some 3 in. thick. A number of passes are worked in each stand and all rolls have to be adjusted for each pass to arrange correct drafting on the web and flange of the beam. Drafts and motor speeds for each pass will be predetermined and a preset screwdown mechanism will enable the operator to achieve all settings at the depression of a single push-button.

The settings of the roll openings for the final pass in the finishing universal stand will determine web and flange thickness of the finished beam. Variations in this setting will enable beams of approximately the same depth and flange width but with different web and flange thicknesses to be produced without the necessity of changing rolls.

It must be made clear, however, that the inner profile of the section remains constant and any variation in flange thickness affects to a small degree the overall depth of the beam. As an example, a 10 in. × 10 in. beam weighing 49 lbs. per foot measures 10 in. × 10 in., but when increased to 60 lbs. per foot, the overall size increases to $10\frac{1}{4}$ in. × $10\frac{1}{16}$ in., i.e., each flange is increased in thickness by $\frac{1}{8}$ in. and the web by $\frac{1}{16}$ in. By further roll adjustment other weights are obtained up to 112 lbs. per foot and the section size for this weight will be $11\frac{3}{8}$ in. × $10\frac{7}{16}$ in.

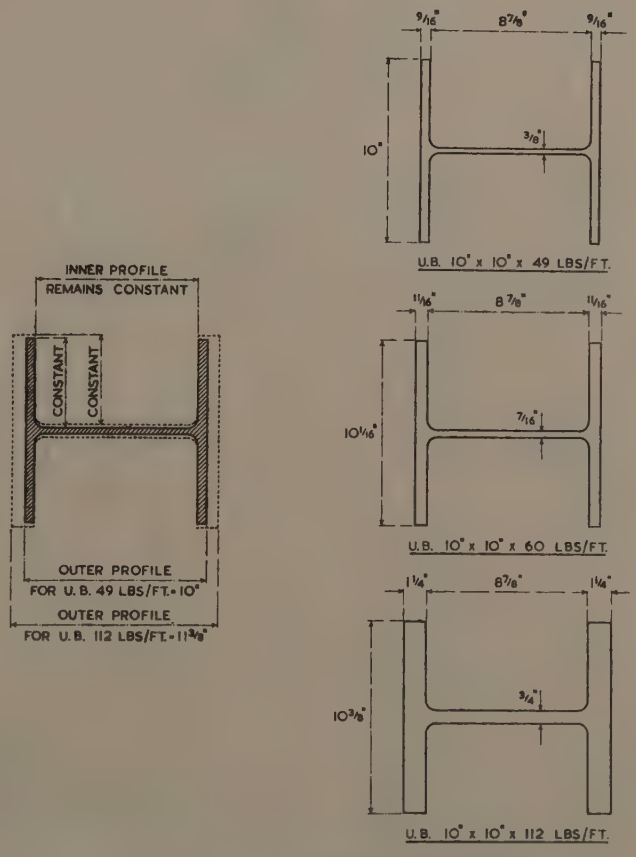


Fig. 7.—Effect of Roll Adjustments

Fig. 7. Provided the ratio of flange to web thickness is approximately the same, any flange thickness up to say $1\frac{1}{2}$ in. for the deepest beams and 3 in. for the heaviest stanchion are technically possible. For commercial reasons the number of beam and stanchion sections to be produced will have to be limited, but a very large range will be available.

It is intended to produce an economical range, based on the American list of sizes, but with additions to meet British requirements. The sizes to be rolled range from 8 in. × $5\frac{1}{4}$ in. × 17 lbs. to 36 in. × $16\frac{1}{2}$ in. × 260 lbs. for beam sections, as shown in Fig. 8, and from 6 in. × 6 in. × 20 lbs. to 14 in. × 16 in. × 426 lbs. for column sections—Fig. 9. Full properties of the proposed range of Universal Beams are given in Appendix ' A.'

SERIAL SIZE INS.	WT. PER FOOT LBS.
36 x 16½	260
	230
36 x 12	194
	170
	150
33 x 11½	152
	130
30 x 10½	132
	116
27 x 10	114
	102
	94

SERIAL SIZE INS.	WT. PER FOOT LBS.
24 x 12	160
	120
	100
24 x 9	94
	84
	76
21 x 13	142
	127
	112
21 x 8¼	82
	73
	68
	62
18 x 7½	66
	60
	55
	50

SERIAL SIZE INS.	WT. PER FOOT LBS.
16 x 7	50
	45
	40
14 x 6¾	45
	38
	34
	30
12 x 6½	36
	31
	27
10 x 5¾	29
	25
	21
8 x 5¼	20
	17

Fig. 8.—Universal Beam Sections

SERIAL SIZE INS.	WT. PER FOOT LBS.
14 x 16	426
	264
	202
	158
COLUMN CORE [16·81 x 16·71]	320
14 x 14½	136
	119
	103
	87
12 x 12	190
	161
	133
	106
	92
	79
	65

SERIAL SIZE INS.	WT. PER FOOT LBS.
10 x 10	112
	89
	72
	60
	49
8 x 8	48
	40
	35
	31
6 x 6	25
	20

Fig. 9.—Universal Column Sections

In deciding the range, close study was given to the features and limitations of the British Standard beams and columns and full information of the demand over a number of years for sections rolled in American mills was made available by the American operating companies.

It is proposed to roll to the American Standard list of rolling tolerances now almost universally accepted.

Two forms of section will be produced :

(a) Beam sections which will be rolled with a small flange taper of 2 degrees, 52 minutes.

(b) Column sections which will have nominally parallel flanges.

The toes of both beam and column sections will be square, Fig. 10.

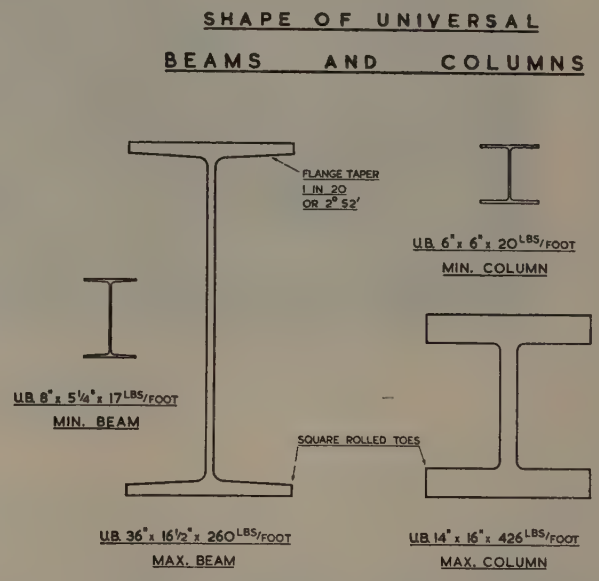

SHAPE OF UNIVERSAL BEAMS AND COLUMNS
FLANGE TAPER 1 IN 20 OR 2° 52'
U.B. 6" x 6" x 20 LBS/FOOT MIN. COLUMN
U.B. 8" x 5¼" x 17 LBS/FOOT MIN. BEAM
SQUARE ROLLED TOES
U.B. 36" x 16½" x 260 LBS/FOOT MAX. BEAM
U.B. 14" x 16" x 426 LBS/FOOT MAX. COLUMN

Fig. 10.—Shape of Universal Beams and Columns

The structural engineer may feel some disappointment that the beam sections have tapered flanges, but he will note that the taper is only one in twenty (2 degrees, 52 minutes), compared with the British Standard of 8°. The saving in beam production costs afforded by this moderate provision is considerable.

The technical advantage of a parallel flange beam section as compared with one having a slightly tapered flange is small, and this is confirmed by experience gained in the United States. In normal structural steelwork by far the greater number of connections occur in the webs of beams and in the flanges of columns, so the taper should not be a matter of serious consequence.

The new beams in a number of cases will be outside the limits of the fabricating equipment installed in some structural shops. This will especially apply to cold sawing of the larger sizes. Sawing to length, either square or skew cutting, is a service which will be available in due course at the mill.

Equipment is to be installed at the mill to split beams through the web to form large tees which will be straightened in special machines prior to despatch.

The present intention is to roll the 44 different sizes of beam sections and the 27 column sections listed in Appendix ' A.' The beams cover a range of 15

serial sizes, many of which have 3 or 4 specified weights per foot. The columns cover a range of 6 serial sizes, one of which has 7 different weights per foot and all have flange widths approximately equal to the depth of section.

In addition to the 21 sets of rolls required to produce this range of universal beams provision has been made to roll 20 sizes of angles, channels and piling. The manufacture of these rolls, some of which weigh over 30 tons each, has presented the British roll maker with many technical problems.

Although it is expected that rolls will have a reasonable life, the magnitude of the roll cost per ton of beams produced can be gathered from the fact that the cost of the initial supply of rolls to cover the range proposed is £1,000,000.

Application of Universal Beams.

Beams.

Beams in the new range in general will have wider flanges than the present British Standard sections. In the case of universal beams of moderate flange width, the rolling technique enables more weight to be concentrated in the flanges than is possible in normal joist rolling mills. Universal beams thus have larger carrying capacities for given depths and weights than the present British Standard sections.

The relationship between section moduli and weights per foot in lbs. for the new range and beams of the present British Standard range is shown in Fig. 11.

It will be seen that in practically all cases the new sections, when compared with their nearest equivalent

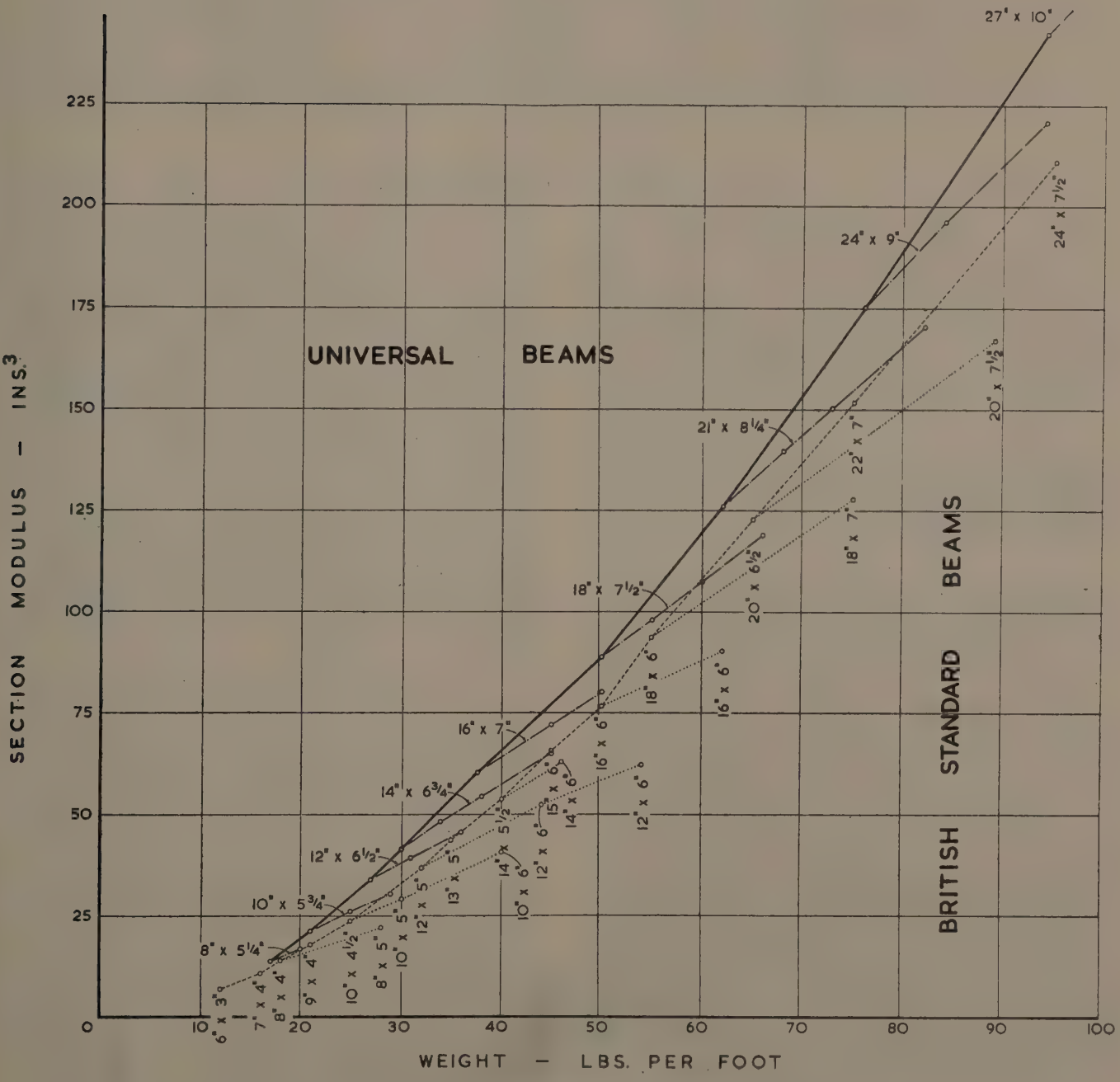


Fig. 11.—Section Modulus/Weight Comparison of Beams

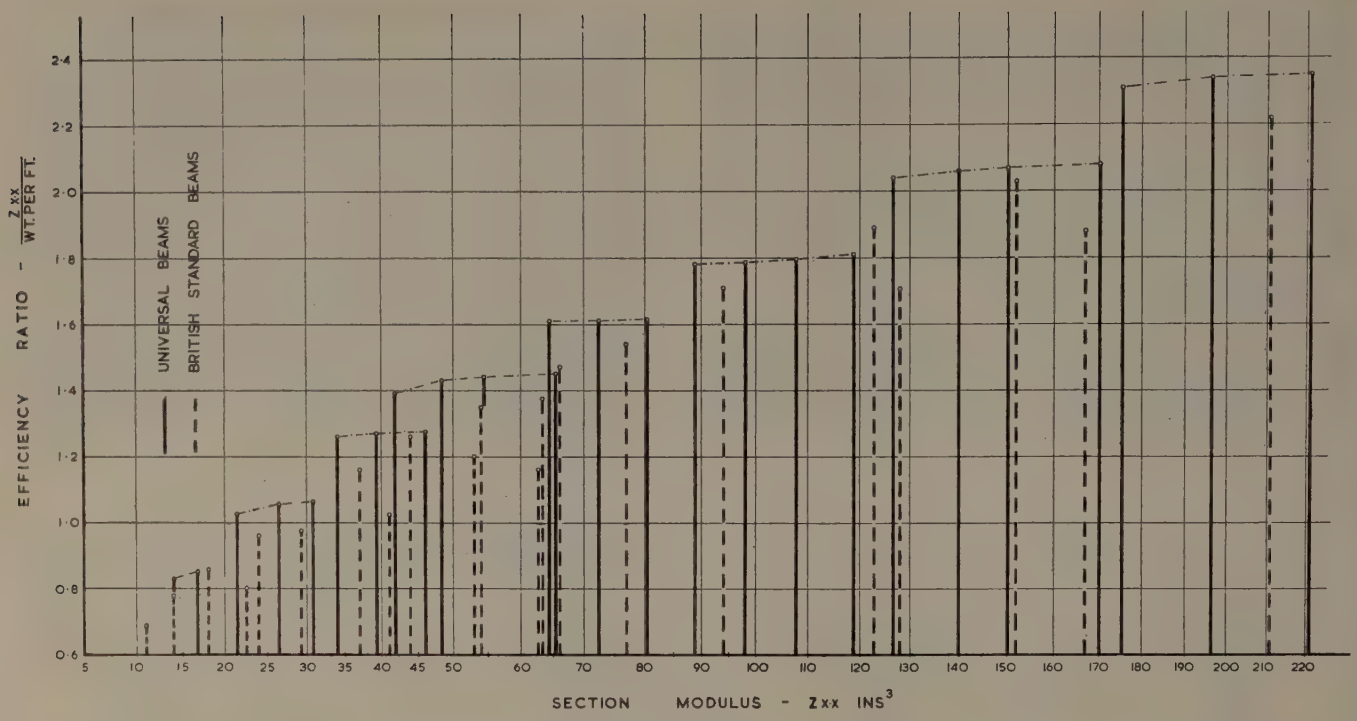


Fig. 12.—Efficiency Comparison of Beams

in the British Standard range, have advantages in either the physical properties or in weight, or both. A comparison between the two indicates that for approximately the same weight per foot, the universal beams provide section moduli as much as 10 per cent above those for the best beams at present available.

The modulus of a beam divided by its weight per foot provides a measure of its efficiency, i.e., its strength as a beam relative to its own weight. This efficiency ratio has been calculated for beams in the British Standard range and in the new Universal Beam range and is shown in Fig. 12.

The good modulus to weight ratios of the wider flange beams is one of the obvious advantages of broad flange beams but the good strength/weight ratio of the smaller beams rolled in universal beam mills compared with their nearest British Standard equivalents in moduli is not so widely appreciated.

It is as well that some stress be laid on this fact. Smaller beams up to say 14 in. deep are a frequent everyday requirement for medium weight structures and savings in weight of steel by using suitable beams from the new range for such work can in total amount to a substantial economy. It will be noted, for example, that for a modulus of about 14 inches^3 the 8 in. beam in the new range has 7.4 per cent better efficiency than the British Standard 8 in. beam. In the 25/30 inches^3 modulus range, the new 10 in. beams show an improvement of about 8 per cent in efficiency over the British Standard 10 in. beams. For a modulus of about 35 inches^3 the new 12 in. × 6½ in. × 27 lbs. per foot beam is 9.8 per cent more efficient than the British Standard 12 in. × 5 in. × 30 lbs. per foot beam and in the 14 in. beam range the improvement in weight/strength ratio is about 6 per cent. It is not surprising that most of the medium weight beams used in the U.S.A. come from their universal beam mills.

The British national tonnage figures show that the consumption of this group of sections in the beam range. namely, 8 in. to 14 in. deep, when resolved into feetage is 200 per cent greater than that supplied in the upper range of 15 in. to 24 in. deep. If the 8 in. to 14 in. beams could have been replaced by Universal beams with their approximately 7½ per cent better efficiency, over 14,000 tons of steel per year would have been released for additional work.

It is generally recognised that some British Standard beams are grossly inefficient whereas there will be a large number of highly efficient beam sizes in the new range up to 24 in. deep. Designers will thus have greater freedom to select beams from the new universal range more suited to the loads to be carried. At present the use of excessively heavy members sometimes cannot be avoided.

The new mill will make available in this country a large number of beam sizes having heavier weights and greater strengths than are rolled here at present. The largest beam section of the new range, namely, 36 in. × 16½ in. × 260 lbs. per foot, has a modulus of 951.1 inches^3, approximately 4½ times the strength of the 24 in. × 7½ in. × 95 lbs. per foot beam which is the deepest British Standard normal section with a modulus of 211.09 inches^3.

Fig. 13 shows the scale difference between some examples of the present British Standard range and the new Universal Beams.

The wider flanges in the new range of beams and also the fact that flange and web thicknesses can be increased in the rolling process, will enable rolled sections to be used in many cases where previously it was necessary to compound British Standard beams. As an example, a 21 in. × 13 in. × 112 lbs. per foot Universal Beam having a modulus of 249.7 inches^3 is comparable with a compound of 21 in. × 12 in.

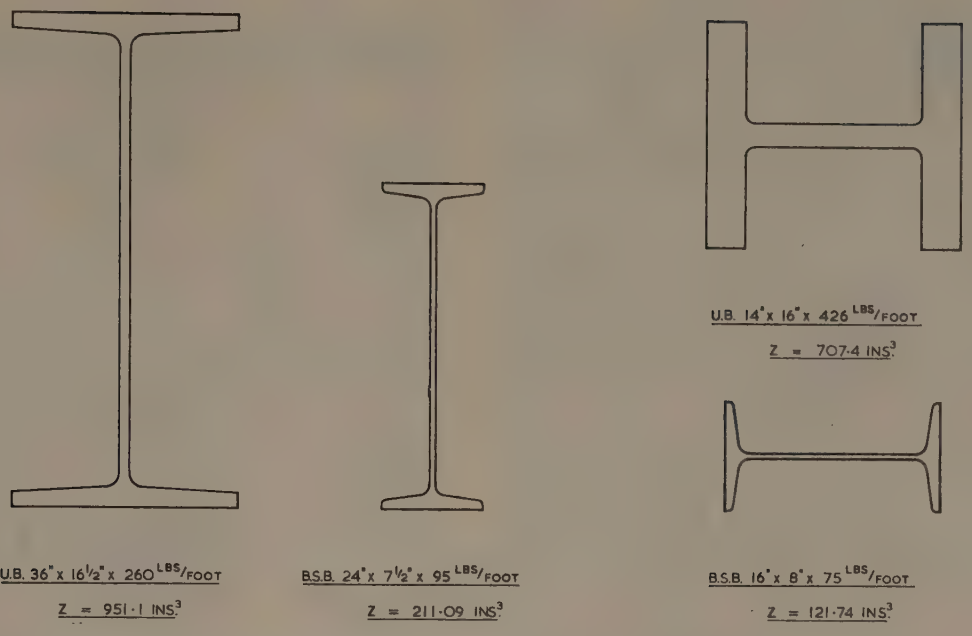

U.B. 36" x 16½" x 260 LBS/FOOT
Z = 951·1 INS.³
B.S.B. 24" x 7½" x 95 LBS/FOOT
Z = 211·09 INS.³
U.B. 14" x 16" x 426 LBS/FOOT
Z = 707·4 INS.³
B.S.B. 16" x 8" x 75 LBS/FOOT
Z = 121·74 INS.³

Fig. 13.—Comparison—Universal and B.S. Beam and Column Sections

composed of a 20 in. × 7½ in. × 89 lbs. per foot British Standard beam and two 12 in. × ½ in. flats—Fig. 14. This section weighs 133½ lbs. per foot and has a modulus of 254.2 inches.[3] The universal beam is 84 per cent of the weight of the compound with a modulus of 98 per cent of that of the compound.

Another example is that the heaviest nominal 24 in. × 12 in. Universal Beam, i.e., 25 in. × 12¼ in. × 160 lbs. per foot, is an excellent substitution for a built-up compound 25¾ in. × 12 in. comprising a 24 in. × 7½ in. × 95 lbs. British Standard beam and two 12 in. × ⅞ in. flange plates. The weight of this compound is 170.2 lbs. per foot with a modulus of 410.5 inches³. In this case the Universal Beam is 95 per cent of the weight of the compound for a practically identical modulus. Whereas in the first example the Universal Beam and the compound are of identical depth, in this case the Universal Beam shows a reduction of ¾ in. in depth compared with the compound.

Numerous similar examples of suitable alternatives for compound members can be found, all of which show a general overall weight economy in the finished girder. Where deeper beams can be utilised to replace compounds greater savings in weight are of course possible.

Where beams are used to replace compounds the gross sectional area of the flange can be utilised. It will not be necessary to consider reduction in flange area due to rivet holing as in the case of built-up compound girders.

It is realised that in substituting the new unplated beams for compounds opportunity of curtailment of flange area is lost and from an academic design standpoint some unnecessary steel must inevitably be used but there will nevertheless be a resulting overall economy.

Far exceeding the importance of saving steel in such cases are, of course, the other savings effected,

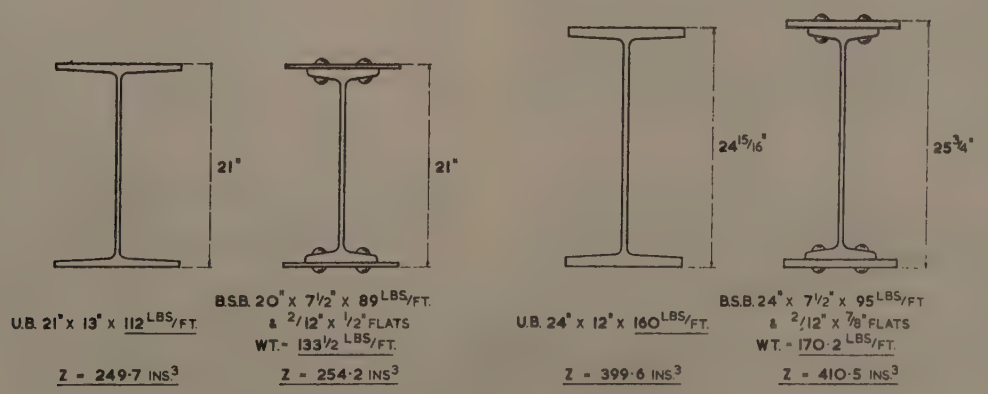

21"
21"
24 15/16"
25¾"
U.B. 21" x 13" x 112 LBS/FT.
Z = 249·7 INS.³
B.S.B. 20" x 7½" x 89 LBS/FT.
& 2/12" x ½" FLATS
WT.- 133½ LBS/FT.
Z = 254·2 INS.³
U.B. 24" x 12" x 160 LBS/FT.
Z = 399·6 INS.³
B.S.B. 24" x 7½" x 95 LBS/FT
& 2/12" x ⅞" FLATS
WT. - 170·2 LBS/FT.
Z = 410·5 INS.³

Fig. 14.—Examples of Rolled Beams Replacing Compounds

namely, the big reduction in fabricating cost and perhaps even more important the reduction in fabricating time.

Another comparison of interest is in regard to the deflection of beams. Since the introduction of the 1948 edition of B.S.S. 449 permitting a maximum flange stress of 10 tons per sq. in. in beams, the limiting deflection of 1/325th of the span often dictates the section of beam to be used. Compared with the present Standard beams, considerable economy can be expected by using the new Universal Beams with their much larger "Moment of Inertia divided by weight" ratio where stiffness is the criterion for design. In certain examples considered savings of weight between 6 and 8 per cent were shown.

Deeper beams from the universal range can be selected in preference to many of the built-up forms of lighter plate girder which have hitherto had to be made from plates welded together or from plates and angles riveted together. It will be remembered that B.S.S.449 permits a maximum flange stress of 10 tons per sq. in. for beams, whereas this must be reduced by 5 per cent for plate girders. Universal Beams thus start with this immediate advantage when used in place of plate girders. As well as the reduction in weight, there is the substantial saving in cost of fabrication, and especially the economy arising from the reduction in fabricating time. Only one section size is required from the mill as against perhaps three or four section sizes to make the built-up girder; furthermore, in such cases the Universal section will dispense with the need for plate now in high demand and will make this available for other constructions—Fig. 15.

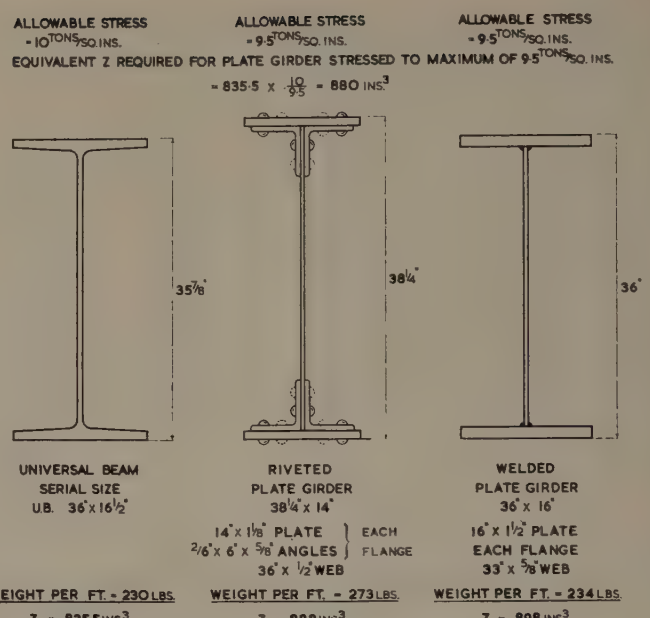

ALLOWABLE STRESS = 10 TONS/SQ. INS.
ALLOWABLE STRESS = 9·5 TONS/SQ. INS.
ALLOWABLE STRESS = 9·5 TONS/SQ. INS.
EQUIVALENT Z REQUIRED FOR PLATE GIRDER STRESSED TO MAXIMUM OF 9·5 TONS/SQ. INS.
= 835·5 x 10/9·5 = 880 INS.³
35⅞"
38¼"
36"
UNIVERSAL BEAM SERIAL SIZE U.B. 36"x16½"
RIVETED PLATE GIRDER 38¼"x 14"
14"x 1⅛" PLATE } EACH
2⅛"x 6"x ⅝" ANGLES } FLANGE
36"x ½" WEB
WELDED PLATE GIRDER 36"x 16"
16"x 1½" PLATE EACH FLANGE
33"x ⅝" WEB
WEIGHT PER FT. = 230 LBS.
Z = 835·5 INS.³
WEIGHT PER FT. = 273 LBS.
Z = 888 INS.³
WEIGHT PER FT. = 234 LBS.
Z = 898 INS.³

Fig. 15.—Universal Beam with Built-up Equivalents

On the Continent it is possible to obtain flat sections with a projecting stub. These have been used in the construction of built-up plate girders by inserting a web plate between two such sections and welding together to form the required girder. There are production difficulties in this type of construction and an improvement to the design can be made using the new beams as girder flanges, by splitting the web along the centre line to form two separate tee bars and by welding in between them an appropriate web plate—Fig. 16. This will permit automatic welding without the risk of the machine fouling the flanges. The splitting of Universal Beams along the web into large tees and the straightening of the latter is a service which will eventually be available from the mill.

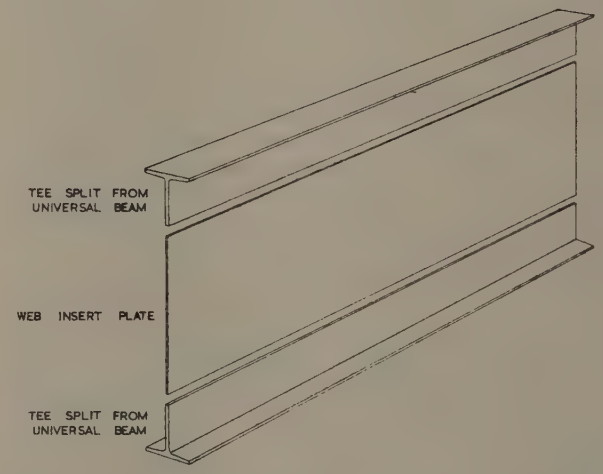


Fig. 16.—Split Universal Beam—Typical Application

A further economical application will be that of using one beam split into two tees to make the upper and lower boom of lattice girders. There are many possibilities for this type of girder as it is unnecessary to introduce gusset plates for the attachment of the diagonal and vertical members of the booms. Similarly, gussets can be avoided in roof truss construction by using the long stalk tees cut from universal beams as rafters—Fig. 17.

Columns.

The wide flange sections of the new range are specially advantageous for columns. The wider flange gives a better distribution of the metal about the weaker axis, with a corresponding increase in the least radius of gyration.

Fig. 18 shows the safe carrying capacities of the universal column sections for lengths of 12 ft. and 25 ft. A selection of the most economical British Standard sections (excluding those covered by B.S.S.2566) for the same lengths are also shown in this Figure. The limitations of the British Standard range of columns are apparent—Fig. 19.

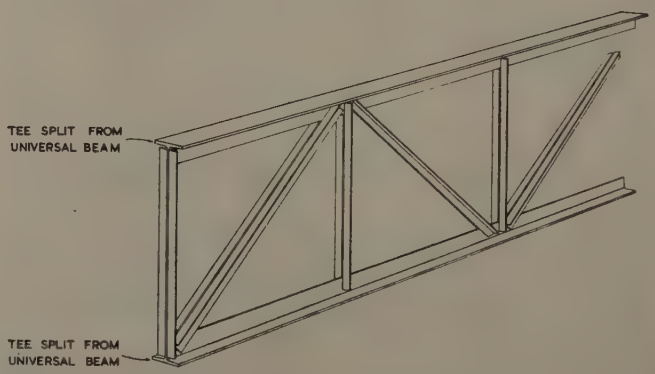


Fig. 17.—Split Universal Beam—Typical Application

SERIAL SIZE INS.	WT. PER FOOT LBS.	SAFE LOAD – TONS EFFECTIVE HEIGHT 12FT	25FT
14 x 16	426	927	708
	264	566	424
	202	430	321
	158	336	249
COLUMN CORE	320	686	518
14 x 14½	136	286	204
	119	250	179
	103	215	153
	87	181	129
12 x 12	190	383	250
	161	324	210
	133	264	171
	106	211	133
	92	182	114
	79	156	97
	65	128	79

SERIAL SIZE INS.	WT. PER FOOT LBS.	SAFE LOAD – TONS EFFECTIVE HEIGHT 12FT	25FT
10 x 10	112	210	118
	89	166	92
	72	133	72·3
	60	111	59·7
	49	89·7	48·0
8 x 8	48	79·8	34·7
	40	65·2	28·0
	35	57·2	24·2
	31	50·2	21·2
6 x 6	25	32·2	—
	20	25·7	—

BRITISH STANDARD COLUMNS.			
16 x 8	75	110	40·5
14 x 8	70	105	39·5
12 x 8	65	99·8	38·6
10 x 8	55	84·1	32·3
9 x 7	50	69·9	24·3
8 x 6	35	40·5	—
6 x 5	25	21·3	—

Fig. 18.—Safe Carrying Capacities of Universal and B.S. Column Sections

It will be seen that the advantages of Universal columns over the British Standard columns are even more marked than for beam sections. For the same weight per foot the Universal column will carry a load approximately 25 per cent greater than the British Standard column on a length of 12 ft. and for longer lengths the load increase is even greater.

It is well known that the British Standard range is lacking in suitable column sizes. The most popular British Standard column section generally available is, undoubtedly, the 10 in. × 8 in. and this is often used as the core section of a column, the flanges being reinforced by flange plates to increase the carrying capacity as required. This form of construction is quite economical in weight of steel but uneconomical from a fabrication standpoint.

The need for this costly fabrication will be largely eliminated when the new Universal range is available. Universal Beams offer an excellent range in column sizes capable of carrying heavy loads without the necessity of flange or web reinforcement.

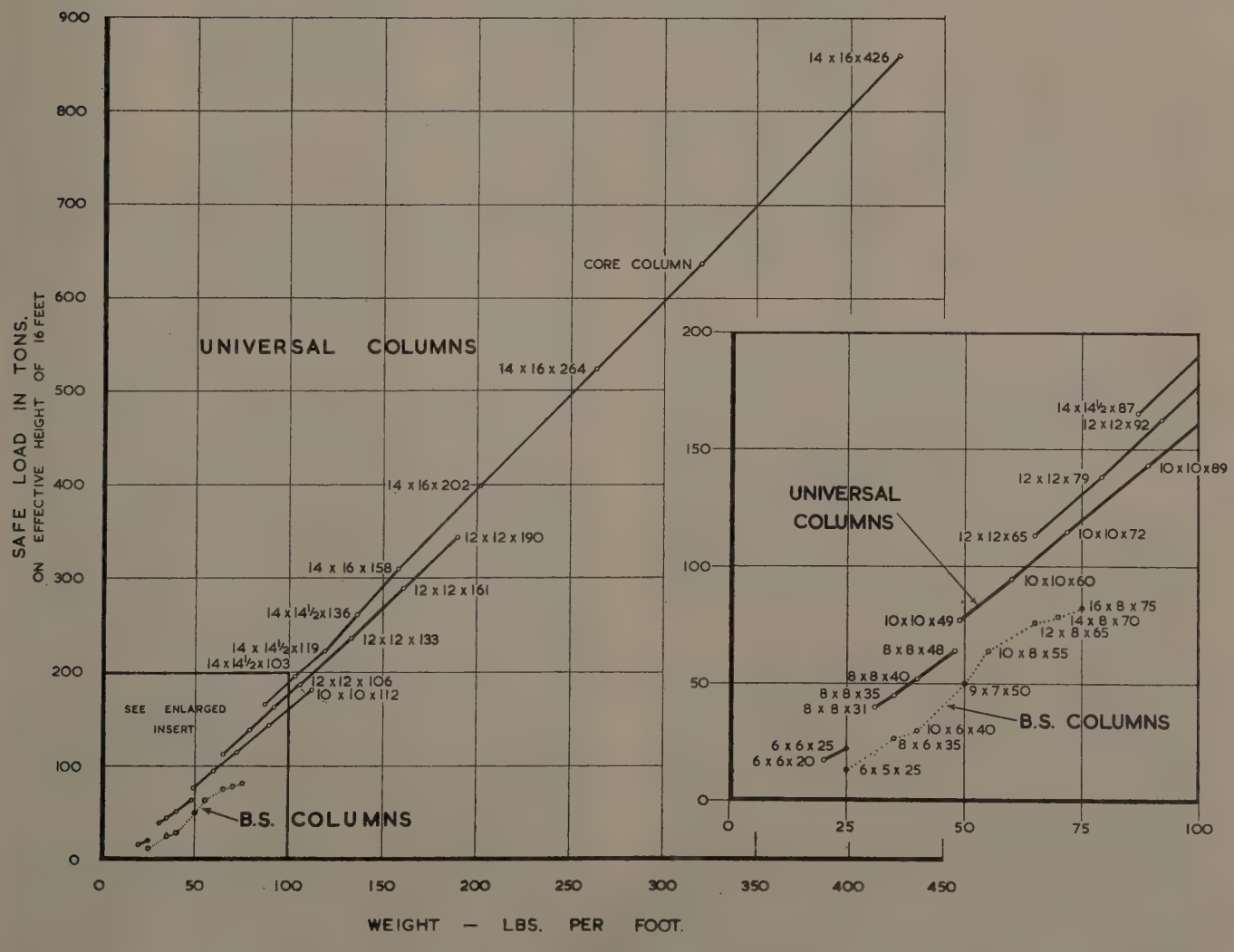


Fig. 19.—Load Carrying Capacity/Weight Comparison of Columns

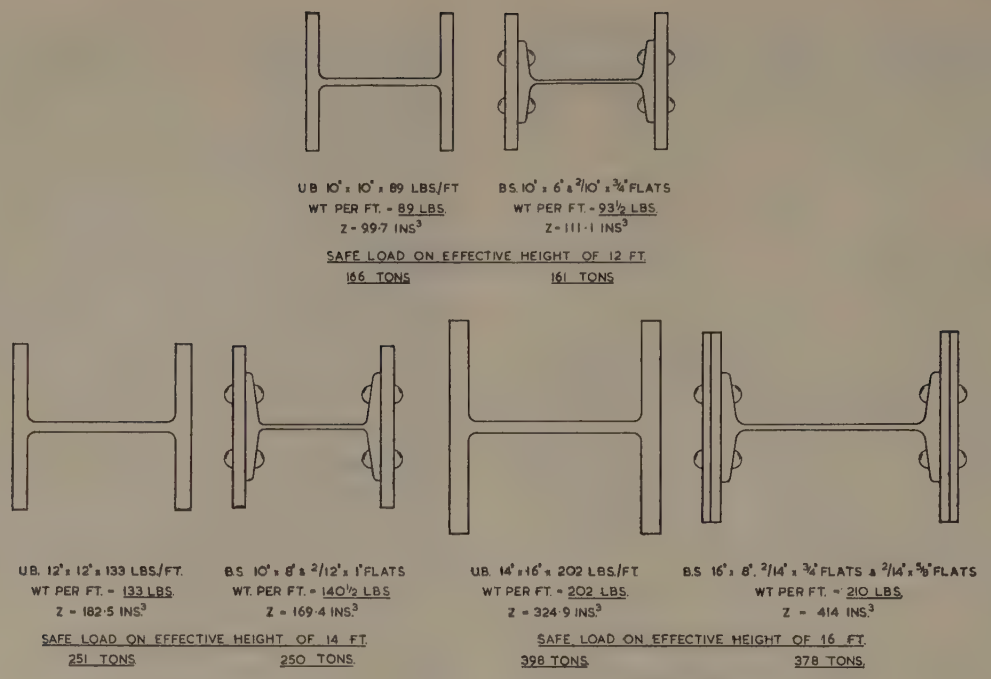

U.B. 10" x 10" x 89 LBS/FT
WT PER FT. = 89 LBS.
Z = 99·7 INS.³
B.S. 10" x 6" & 2/10" x ¾" FLATS
WT PER FT. = 93½ LBS.
Z = 111·1 INS.³
SAFE LOAD ON EFFECTIVE HEIGHT OF 12 FT.
166 TONS
161 TONS
U.B. 12" x 12" x 133 LBS./FT.
WT PER FT. = 133 LBS.
Z = 182·5 INS.³
B.S. 10" x 8" & 2/12" x 1" FLATS
WT. PER FT. = 140½ LBS
Z = 169·4 INS.³
U.B. 14" x 16" x 202 LBS./FT.
WT PER FT. = 202 LBS.
Z = 324·9 INS.³
B.S. 16" x 8", 2/14" x ¾" FLATS & 2/14" x ⅝" FLATS
WT PER FT. = 210 LBS.
Z = 414 INS.³
SAFE LOAD ON EFFECTIVE HEIGHT OF 14 FT.
251 TONS.
250 TONS.
SAFE LOAD ON EFFECTIVE HEIGHT OF 16 FT.
398 TONS.
378 TONS.

Fig. 20.—Universal Column with Built-up Equivalent

The most economical column shape of course is one in which the radius of gyration is the same about all axes. The structural engineer, however, is generally concerned only with the two principal axes and for a given column length requires these to be as nearly alike as possible. The new range approximates much more closely to this ideal than the present British Standard range—Fig. 20.

A further advantage attained by the use of Universal column sections is the better web thickness to depth ratio. Where beams having heavy end reactions trim into the web of columns, the thin webs of the present range have often proved to be a serious disadvantage. Moreover, if the loading conditions demand heavily compounded flanges, the thin web becomes increasingly out of proportion and inadequate. The marked superiority of the Universal Beams in this respect is apparent at once from an inspection of the web thicknesses available, from which it will be seen that the web thickness increases at approximately the same rate as the flange thickness.

Consideration of the possibility of failure of Universal column sections due to local buckling of the toes at the compression flange, shows that any size in the range will fail as a whole before this condition is reached. Investigation has also shown that Universal column sections will not be prone to failure due to elastic instability in torsion.

In very special cases of heavy columns where even the largest and heaviest section of Universal column is inadequate, as may arise in multi-storey building construction, there will be a core section available. This is a 14 in. × 16 in. × 320 lbs. per foot Universal section rolled primarily for the purpose of adding outer plates and slabs, either by riveting or welding, to form the required section. Obviously such sections will carry exceptionally heavy loads and even with

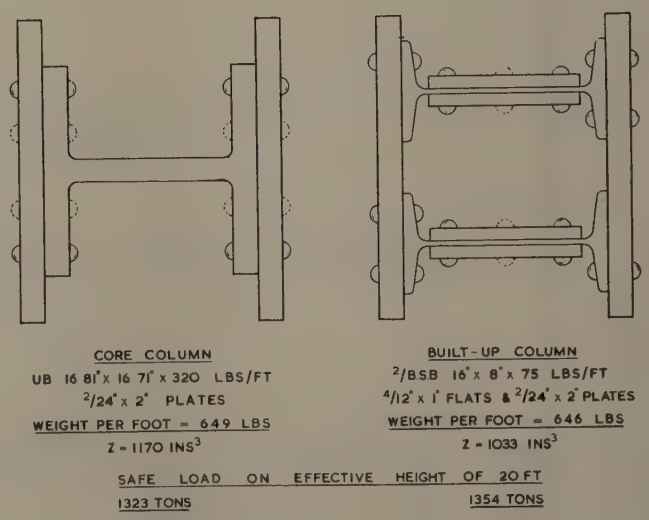
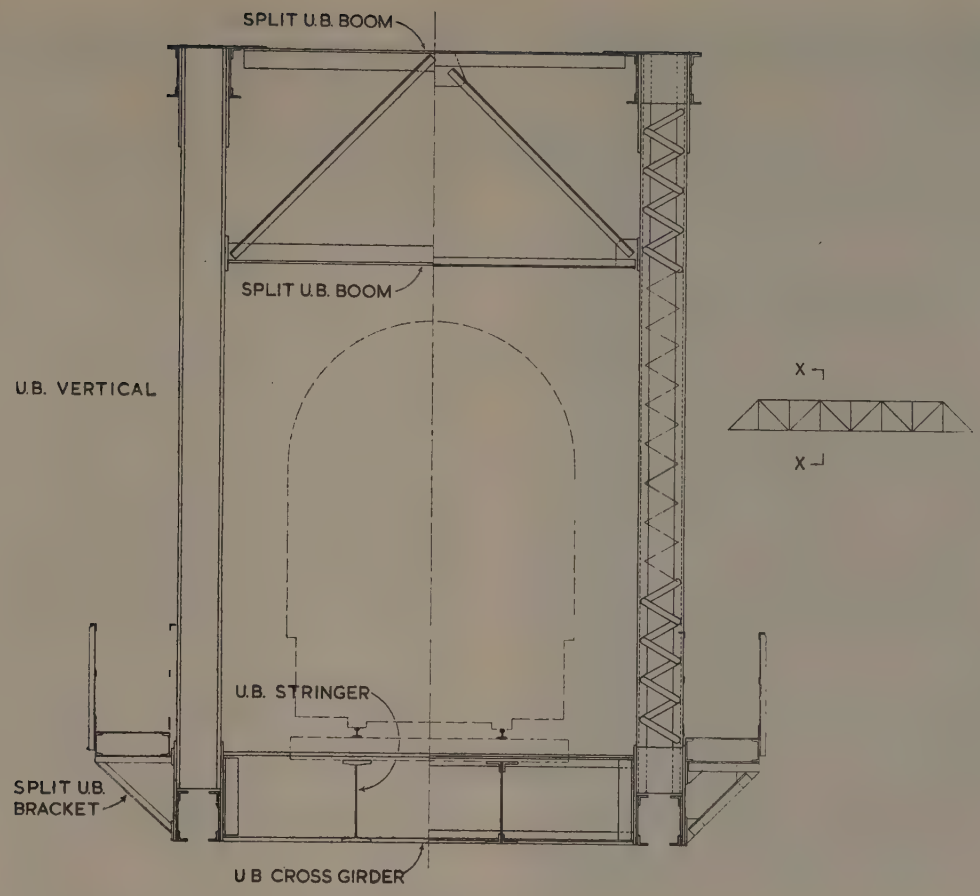

CORE COLUMN
UB 16 81" x 16 71" x 320 LBS/FT
2/24" x 2" PLATES
WEIGHT PER FOOT = 649 LBS
Z = 1170 INS.³
BUILT-UP COLUMN
2/BSB 16" x 8" x 75 LBS/FT
4/12" x 1" FLATS & 2/24" x 2" PLATES
WEIGHT PER FOOT = 646 LBS
Z = 1033 INS.³
SAFE LOAD ON EFFECTIVE HEIGHT OF 20 FT
1323 TONS
1354 TONS

Fig. 21.—Heavy Universal Core Column with Built-up Equivalent

the workmanship required in the formation of such columns they will compare very favourably with members which at present have to be built up either from three slabs welded in " H " form or from a section of which a British Standard beam or beams form the core—Fig. 21.

The designer of a building of several storeys will appreciate that by keeping to one serial size for the columns it will be possible to obtain all column lengths from the same rolling. Thus, if 10 in. × 10 in. were the basic size, the lower lengths could be 112 lbs. per foot reducing to 89 lbs., then to 72 lbs. and 60 lbs. for intermediate lengths, finishing with upper lengths of 49 lbs. per foot. The advantage gained in obtaining all sections from the same rolling is considerable.



CROSS SECTION X-X

Fig. 22.—Universal Beams in Bridge Work

Fabricators are well aware of the delay and general frustration which occurs as a result of having to use many different sections in the design of storey buildings with waiting periods between rollings.

In the larger Universal beam sections, the wide flange will permit of four rows of bolts or rivets in line. This will be of advantage to the structural designer as it will allow him to simplify the connections for incoming members, etc. and will minimise those difficulties which have hitherto applied when dealing with moment connections of beams to the flanges of columns. The extra rows of rivets can also be used to simplify the details of other connections transmitting very large moments, such as at column bases, and so reduce the amount of material used in such constructions.

Another feature of Universal Beams which will be of considerable advantage in special circumstances is that the new sections will be rolled with square toes compared with the rounded toes of beams of the present British Standard range. The square toes or edges should eliminate much structural shop preparation for welding purposes.

General.

The advantages to be gained by the use of the new Universal Beams in all types of steel construction are apparent. The design engineer will have more freedom of choice to bring overall economy into his designs by using sections lighter in weight but of adequate load carrying capacity. Sections which hitherto have needed to be reinforced with flange plates, either as girders or columns, will be supplied as rolled sections, thereby reducing appreciably the large amount of shop fabrication at present needed.

Reference has been made to the use of the more economical Universal Beam in place of the lighter forms of built-up girder. A notable application of this will be in bridgework, where the new beams can be introduced as cross girders and stringer girders with advantage. They can also be used as vertical and diagonal members in truss span bridges. Fig. 22 shows half cross sections of a typical through span railway bridge. The adoption of Universal sections clearly shows the considerable saving in what hitherto has been complicated and expensive fabrication.

An application particularly suitable for heavy Universal beams will be in the road development programme which will call for considerable lengths of elevated highways where fly-over crossings are involved—Fig. 23.

Railway electrical engineers will find the new Universal beams excellent for the columns supporting the girders carrying overhead conductors.

Crane gantry girders of the lighter type provide another striking example where savings will be shown. It has been common practice to stiffen the top and

Fig. 23.—Universal Beams in Highway Development

bottom flanges of British Standard joists with a channel or a flat, not only for strength purposes but to give lateral stability. The new range with wider flanges will give an excellent choice of beams requiring little fabrication to provide crane gantry girders of equivalent strength and lateral stability.

The new sections can be used with advantage in rigid frame welded structures, especially for larger spans. In the past it has frequently been necessary to produce such frames from three plates welded together.

A wide field of application for the new sections will be found not only in structural engineering and bridge building but also in general engineering, shipbuilding and for such purposes as bearing piles.

Construction of machinery bedplates and turbine foundation supports should become a simplified matter when Universal Beams are used especially when the upper flanges are required to be machined dead level. Such structures previously constructed of plate girders and compounds involved a large amount of shop fabrication and the costly operation of counter-sinking rivets in the upper flanges.

For bearing piles the square column sizes are obviously suitable. In this connection corrosion is often an important factor and increased web thickness may be desirable. To meet this requirement special variations of the column sections having web and flanges of equal thickness can readily be rolled.

One other matter worthy of mention is that the availability of Universal Beams should lead to a reduction in Drawing Office detail and design work. Plain sections will replace previously built-up sections both for columns and girders and riveting will be considerably curtailed and connections simplified.

A supplement to the Dorman Long Handbook listing the range of Universal Beams to be rolled and their properties will be made available as soon as supplies of the beams are available.

Until the new Handbook becomes available, designs can be prepared from the properties given for the new range in Appendix ' A ' in which the opportunity has been taken to include the plastic moduli of the new sections. In preparing future designs, structural engineers will bear in mind that ultimately these new sections are intended substantially to replace the British Standard range of beams.

Actual steel structures have been redesigned using the new range of universal beams. The results show savings in weight varying from 5 per cent to 10 per cent. They also show in most cases substantial reductions in fabricating costs with big savings in the time required for manufacture. Fig. 24 shows Universal Beams in a Multi Storey Building (U.S.A.).

Structural engineering is of vital importance, contributing to industrial development in almost every field. The vast new venture now nearing completion at Lackenby should assure to the structural engineers of this country supplies of the most efficient and economical rolled steel sections.

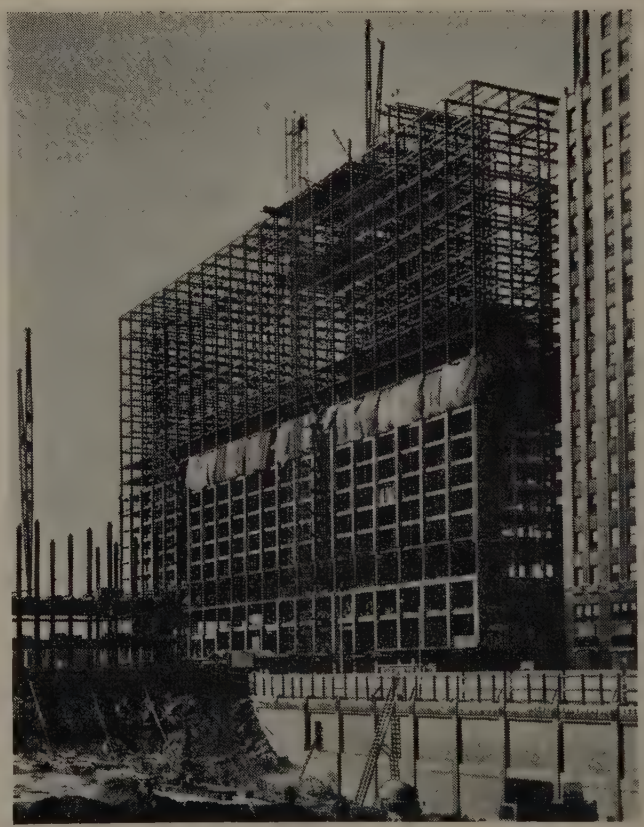


Fig. 24.—Universal Beams in a Multi Storey Building

In Appendix ' A ' which follows, acknowledgment is due to the Bethlehem Steel Co., for information made available in the compilation of the properties of the sections.

APPENDIX 'A'
UNIVERSAL BEAM SECTIONS

Serial Size	Wt. per ft.	Depth of Section a	Width of Section b	THICKNESS Web t_1	THICKNESS Flange t_2	Root Radius r	Slope inside Flange	Depth between Fillets d	Area of Section	Moments of Inertia About x—x	Moments of Inertia About y—y	Radius of Gyration About x—x	Radius of Gyration About y—y	Elastic Modulus About x—x	Elastic Modulus About y—y	Plastic Modulus About x—x	Plastic Modulus About y—y	NOMINAL SIZE
ins.	lbs.	ins.	ins.	ins.	ins.	ins.	%	ins.	ins.[2]	ins.[4]	ins.[4]	ins.	ins.	ins.[3]	ins.[3]	ins.[3]	ins.[3]	ins.
36 × 16½	260	36.24	16.555	.845	1.440	.95	5.0	31.16	76.56	17234	1021	15.00	3.65	951.1	123.3	1076	195.6	36¼ × 16 9/16
	230	35.88	16.475	.765	1.260	.95	5.0	31.16	67.73	14988	870.9	14.88	3.59	835.5	105.7	942.5	168.2	35⅞ × 16½
36 × 12	194	36.48	12.117	.770	1.260	.75	5.0	32.25	57.11	12103	355.4	14.56	2.49	663.6	58.7	766.8	94.7	36½ × 12⅛
	170	36.16	12.027	.680	1.100	.75	5.0	32.25	49.98	10470	300.6	14.47	2.45	579.1	50.0	667.0	80.7	36 3/16 × 12
	150	35.84	11.972	.625	.940	.75	5.0	32.25	44.16	9012.1	250.4	14.29	2.38	502.9	41.8	580.0	67.8	35 13/16 × 12
33 × 11½	152	33.50	11.565	.635	1.055	.70	5.0	29.78	44.71	8147.6	256.1	13.50	2.39	486.4	44.3	558.0	71.2	33½ × 11 9/16
	130	33.10	11.510	.580	.855	.70	5.0	29.78	38.26	6699.0	201.4	13.23	2.29	404.8	35.0	465.9	56.7	33⅛ × 11½
30 × 10½	132	30.30	10.551	.615	1.000	.65	5.0	26.82	38.83	5753.1	185.0	12.17	2.18	379.7	35.1	436.7	56.4	30 5/16 × 10 9/16
	116	30.00	10.500	.564	.850	.65	5.0	26.82	34.13	4919.1	153.2	12.00	2.12	327.9	29.2	377.5	47.2	30 × 10½
27 × 10	114	27.28	10.070	.570	.932	.60	5.0	24.04	33.53	4080.5	149.6	11.03	2.11	299.2	29.7	342.7	47.6	27¼ × 10 1/16
	102	27.07	10.018	.518	.827	.60	5.0	24.04	30.01	3604.1	129.5	10.96	2.08	266.3	25.9	304.5	41.5	27 1/16 × 10
	94	26.91	9.990	.490	.747	.60	5.0	24.04	27.65	3266.8	115.1	10.87	2.04	242.8	23.0	277.8	37.1	26 15/16 × 10
24 × 12	160	24.92	12.264	.732	1.235	.65	5.0	20.93	47.05	4979.2	359.7	10.29	2.77	399.6	58.7	454.4	92.9	24 15/16 × 12¼
	120	24.31	12.088	.556	.930	.65	5.0	20.93	35.29	3635.3	254.0	10.15	2.68	299.1	42.0	336.3	66.6	24 5/16 × 12 1/16
	100	24.00	12.000	.468	.775	.65	5.0	20.93	29.43	2987.3	203.6	10.08	2.63	248.9	33.9	278.4	54.0	24 × 12
24 × 9	94	24.29	9.061	.516	.872	.50	5.0	21.38	27.63	2683.0	102.2	9.85	1.92	220.9	22.6	252.7	36.1	24 5/16 × 9 1/16
	84	24.09	9.015	.470	.772	.50	5.0	21.38	24.71	2364.3	88.3	9.78	1.89	196.3	19.6	224.1	31.4	24 1/16 × 9
	76	23.91	8.985	.440	.682	.50	5.0	21.38	22.37	2096.4	76.5	9.68	1.85	175.4	17.0	200.3	27.4	23 15/16 × 9
21 × 13	142	21.46	13.132	.659	1.095	.65	5.0	17.72	41.78	3403.9	386.0	9.03	3.04	317.2	58.8	356.9	92.6	21 7/16 × 13⅛
	127	21.24	13.061	.588	.985	.65	5.0	17.72	37.38	3018.0	338.6	8.99	3.01	284.2	51.8	318.1	81.8	21¼ × 13 1/16
	112	21.00	13.000	.527	.865	.65	5.0	17.72	32.97	2621.4	289.7	8.92	2.96	249.7	44.6	278.3	70.5	21 × 13
21 × 8¼	82	21.44	8.342	.502	.840	.50	5.0	18.61	24.12	1827.8	77.1	8.70	1.79	170.5	18.5	195.2	29.5	21 7/16 × 8 5/16
	73	21.24	8.295	.455	.740	.50	5.0	18.61	21.46	1600.3	66.2	8.64	1.76	150.7	16.0	172.1	25.5	21⅛ × 8 5/16
	68	21.13	8.270	.430	.685	.50	5.0	18.61	20.02	1478.3	60.4	8.59	1.74	139.9	14.6	159.6	23.4	21⅛ × 8¼
	62	20.99	8.240	.400	.615	.50	5.0	18.61	18.23	1326.8	53.1	8.53	1.71	126.4	12.9	144.1	20.7	21 × 8¼
18 × 7½	66	18.40	7.592	.450	.770	.40	5.0	15.92	19.40	1096.8	53.2	7.52	1.66	119.2	14.0	136.0	22.3	18⅜ × 7 9/16
	60	18.25	7.558	.416	.695	.40	5.0	15.92	17.64	984.0	47.1	7.47	1.63	107.8	12.5	122.8	19.9	18¼ × 7 9/16
	55	18.12	7.532	.390	.630	.40	5.0	15.92	16.19	889.9	42.0	7.41	1.61	98.2	11.1	111.7	17.8	18⅛ × 7 9/16
	50	18.00	7.500	.358	.570	.40	5.0	15.92	14.71	800.6	37.2	7.38	1.59	89.0	9.91	100.9	15.8	18 × 7½
16 × 7	50	16.25	7.073	.380	.628	.40	5.0	14.07	14.70	655.4	34.8	6.68	1.54	80.7	9.84	91.6	15.7	16¼ × 7 1/16
	45	16.12	7.039	.346	.563	.40	5.0	14.07	13.24	583.3	30.5	6.64	1.52	72.4	8.66	82.0	13.8	16⅛ × 7 1/16
	40	16.00	7.000	.307	.503	.40	5.0	14.07	11.77	515.5	26.5	6.62	1.50	64.4	7.58	72.7	12.1	16 × 7
14 × 6¾	45	14.33	6.820	.357	.618	.40	5.0	12.17	13.23	468.1	30.7	5.95	1.52	65.3	9.01	73.9	14.3	14 5/16 × 6 13/16
	38	14.12	6.776	.313	.513	.40	5.0	12.17	11.17	385.3	24.6	5.87	1.49	54.6	7.28	61.5	11.6	14⅛ × 6¾
	34	14.00	6.750	.287	.453	.40	5.0	12.17	10.00	339.2	21.3	5.83	1.46	48.5	6.30	54.5	10.1	14 × 6¾
	30	13.86	6.733	.270	.383	.40	5.0	12.17	8.81	289.6	17.5	5.73	1.41	41.8	5.21	47.1	8.38	13⅞ × 6¾
12 × 6½	36	12.24	6.565	.305	.540	.35	5.0	10.34	10.59	280.8	23.7	5.15	1.50	45.9	7.23	51.5	11.4	12¼ × 6 9/16
	31	12.09	6.525	.265	.465	.35	5.0	10.34	9.12	238.4	19.8	5.11	1.47	39.4	6.07	44.0	9.60	12 1/16 × 6½
	27	11.96	6.500	.240	.400	.35	5.0	10.34	7.97	204.2	16.6	5.06	1.44	34.1	5.11	38.0	8.12	11 15/16 × 6½

UNIVERSAL BEAM SECTIONS—*continued*

Serial Size ins.	Wt. per ft. lbs.	Depth of Section a ins.	Width of Section b ins.	THICKNESS Web t_1 ins.	THICKNESS Flange t_2 ins.	Root Radius r ins.	Slope inside Flange %	Depth between Fillets d ins.	Area of Section ins.²	Moments of Inertia About x—x ins.⁴	Moments of Inertia About y—y ins.⁴	Radius of Gyration About x—x ins.	Radius of Gyration About y—y ins.	Elastic Modulus About x—x ins.³	Elastic Modulus About y—y ins.³	Plastic Modulus About x—x ins.³	Plastic Modulus About y—y ins.³	NOMINAL SIZE ins.
10 × 5¾	29	10.22	5.799	.289	.500	.30	5.0	8.51	8.53	157.3	15.2	4.29	1.34	30.8	5.25	34.6	8.27	10¼ × 5 13/16
	25	10.08	5.762	.252	.430	.30	5.0	8.51	7.35	133.2	12.7	4.26	1.31	26.4	4.40	29.6	6.95	10 1/16 × 5¾
	21	9.90	5.750	.240	.340	.30	5.0	8.51	6.19	106.3	9.74	4.14	1.25	21.5	3.39	24.1	5.42	9⅞ × 5¾
8 × 5¼	20	8.14	5.268	.248	.378	.30	5.0	6.69	5.88	69.2	8.50	3.43	1.20	17.0	3.23	19.1	5.11	8⅛ × 5¼
	17	8.00	5.250	.230	.308	.30	5.0	6.69	5.00	56.4	6.72	3.36	1.16	14.1	2.56	15.8	4.09	8 × 5¼

UNIVERSAL—COLUMN SECTIONS

Serial Size ins.	Wt. per ft. lbs.	Depth of Section a ins.	Width of Section b ins.	THICKNESS Web t_1 ins.	THICKNESS Flange t_2 ins.	Root Radius r ins.	Slope inside Flange %	Depth between Fillets d ins.	Area of Section ins.²	Moments of Inertia About x—x ins.⁴	Moments of Inertia About y—y ins.⁴	Radius of Gyration About x—x ins.	Radius of Gyration About y—y ins.	Elastic Modulus About x—x ins.³	Elastic Modulus About y—y ins.³	Plastic Modulus About x—x ins.³	Plastic Modulus About y—y ins.³	NOMINAL SIZE ins.
14 × 16	426	18.69	16.695	1.875	3.033	.60	0	11.42	125.25	6610.3	2359.5	7.26	4.34	707.4	282.7	869.4	434.1	18 11/16 × 16 11/16
	264	16.50	16.025	1.205	1.938	.60	0	11.42	77.63	3526.0	1331.2	6.74	4.14	427.4	166.1	502.2	253.7	16½ × 16
	202	15.63	15.750	.930	1.503	.60	0	11.42	59.39	2538.8	979.7	6.54	4.06	324.9	124.4	373.4	189.3	15⅝ × 15¾
	158	15.00	15.550	.730	1.188	.60	0	11.42	46.47	1900.6	745.0	6.40	4.00	253.4	95.8	286.1	145.5	15 × 15 9/16
Column Core	320	16.81	16.710	1.890	2.093	.60	0	11.42	94.12	4141.7	1635.1	6.63	4.17	492.8	195.7	591.9	303.8	16 13/16 × 16 11/16
14 × 14½	136	14.75	14.740	.660	1.063	.60	0	11.42	39.98	1593.0	567.8	6.31	3.77	216.0	77.0	242.7	117.0	14¾ × 14¾
	119	14.50	14.650	.570	.938	.60	0	11.42	34.99	1373.1	491.8	6.26	3.75	189.4	67.1	211.0	101.8	14½ × 14⅝
	103	14.25	14.575	.495	.813	.60	0	11.42	30.26	1165.8	419.7	6.21	3.72	163.6	57.6	180.9	87.2	14¼ × 14 9/16
	87	14.00	14.500	.420	.688	.60	0	11.42	25.56	966.9	349.7	6.15	3.70	138.1	48.2	151.4	73.0	14 × 14½
12 × 12	190	14.38	12.670	1.060	1.736	.60	0	9.71	55.86	1892.6	589.7	5.82	3.25	263.2	93.1	311.3	142.6	14⅜ × 12 11/16
	161	13.88	12.515	.905	1.486	.60	0	9.71	47.38	1541.9	486.3	5.70	3.20	222.2	77.7	259.1	118.8	13⅞ × 12½
	133	13.38	12.365	.755	1.236	.60	0	9.71	39.11	1221.3	389.9	5.59	3.16	182.5	63.1	209.7	96.2	13⅜ × 12⅜
	106	12.88	12.230	.620	.986	.60	0	9.71	31.19	930.7	300.9	5.46	3.11	144.5	49.2	163.5	74.9	12⅞ × 12¼
	92	12.62	12.155	.545	.856	.60	0	9.71	27.06	788.9	256.4	5.40	3.08	125.0	42.2	140.3	64.2	12⅝ × 12⅛
	79	12.38	12.080	.470	.736	.60	0	9.71	23.22	663.1	216.4	5.34	3.05	107.1	35.8	119.2	54.4	12⅜ × 12 1/16
	65	12.12	12.000	.390	.606	.60	0	9.71	19.11	533.4	174.6	5.28	3.02	88.0	29.1	97.0	44.1	12⅛ × 12
10 × 10	112	11.38	10.415	.755	1.248	.50	0	7.88	32.92	718.7	235.4	4.67	2.67	126.3	45.2	147.5	69.1	11⅜ × 10 7/16
	89	10.88	10.275	.615	.998	.50	0	7.88	26.19	542.4	180.6	4.55	2.63	99.7	35.2	114.4	53.6	10⅞ × 10¼
	72	10.50	10.170	.510	.808	.50	0	7.88	21.18	420.7	141.8	4.46	2.59	80.1	27.9	90.6	42.4	10½ × 10 3/16
	60	10.25	10.075	.415	.683	.50	0	7.88	17.66	343.7	116.5	4.41	2.57	67.1	23.1	75.0	35.1	10¼ × 10 1/16
	49	10.00	10.000	.340	.558	.50	0	7.88	14.40	272.9	93.0	4.35	2.54	54.6	18.6	60.3	28.2	10 × 10
8 × 8	48	8.50	8.117	.405	.683	.40	0	6.33	14.11	183.7	60.9	3.61	2.08	43.2	15.0	49.0	22.8	8½ × 8⅛
	40	8.25	8.077	.365	.558	.40	0	6.33	11.76	146.3	49.0	3.53	2.04	35.5	12.14	39.8	18.5	8¼ × 8 1/16
	35	8.12	8.027	.315	.493	.40	0	6.33	10.30	126.5	42.5	3.50	2.03	31.1	10.60	34.7	16.1	8⅛ × 8
	31	8.00	8.000	.288	.433	.40	0	6.33	9.12	109.7	37.0	3.47	2.01	27.4	9.24	30.4	14.0	8 × 8
6 × 6	25	6.37	6.080	.320	.454	.30	0	4.86	7.35	53.3	17.0	2.69	1.52	16.7	5.60	18.9	8.55	6⅜ × 6 1/16
	20	6.20	6.018	.258	.369	.30	0	4.86	5.93	41.9	13.4	2.66	1.50	13.5	4.46	15.1	6.79	6 3/16 × 6

Institution Notices and Proceedings

FORTHCOMING MEETINGS

The following meetings will be held at 11, Upper Belgrave Street, London, S.W.1.

Thursday, November 14th, 1957

Ordinary Meeting, 6 p.m., when Mr. F. R. Bullen, B.Sc.(Eng.), M.I.Struct.E., M.I.C.E. (Honorary Treasurer) will give a paper on " Structural Features of the new Binns Store in Middlesbrough."

Thursday, November 28th, 1957

Ordinary General Meeting for the election of members 5.55 p.m., followed by an Ordinary Meeting at 6 p.m., when Mr. L. A. Chackett, F.R.I.B.A., F.R.I.C.S., will give a paper on " The Relationship of the Architect and the Structural Engineer."

Thursday, December 12th, 1957
Maclachlan Lecture 1957

An Ordinary Meeting will be held at 6 p.m. for the presentation of the Maclachlan Lecture. The lecture, " Tandem Ferry Aprons for the Canadian Pacific Railway at Vancouver and Nanaimo, B.C., Canada," will be given by Mr. P. L. Easterbrook, B.Sc. (Graduate).

Thursday, December 19th, 1957

Ordinary General Meeting, 5 p.m. This meeting is for the election of members and is open only to corporate members of the Institution.

Thursday, January 9th, 1958

Ordinary Meeting at 6 p.m., when Mr. J. S. Terrington, B.Sc.(Eng.), A.M.I.Struct.E., A.M.I.C.E., will give a paper on " The Calculation of Bending and Torsional Effects in Girders."

Thursday, January 23rd, 1958

Joint Meeting with the Reinforced Concrete Association at 6 p.m., when Professor A. L. L. Baker, D.Sc.(Eng.), B.Tech., Hon. A.C.G.I., M.I.Struct.E., M.I.C.E., will give a paper on " The Work of the European Committee on Concrete."

Members wishing to bring guests to the Ordinary Meetings announced above are requested to apply to the Secretary for tickets of admission.

EXAMINATIONS, JULY, 1957

Pass List

The Examinations of the Institution were held in July, 1957, at the usual centres in the United Kingdom.

Seventy-eight candidates took the Graduateship Examination, and 428 took the Associate-Membership Examination. Of these, 58 passed the Graduateship Examination and 148 passed the Associate-Membership Examination.

The names of the successful candidates are :—

Graduateship Examination

Ali, Meer Mahmood.
Awad, Osman.
Bagshaw, Grenville.
Banerjee, Hari Nath.
Bell, Frank.
Bielinski, Tadeusz.
Blundell, Robert Paul Ward.
Bowen, Lyndon Parry.
Broad, John Osborne.
Burman, Ralph.
Burr, Wilfred Alec.
Chandra, Tirtha Renu.
Clarke, Karl Nicholas Riley.
Corry, John Percival.
Cudden, Robert.
Cundy, Christopher John.
Currie, Malcolm Kenneth.
Dolinski, Bohdan Jan.
Doughty, Geoffrey.
Dulson, William.
Ellison, Morville Vernon.
Farmer, Newton.
Filmore, Maurice Ernest Fuce.
Foulger, Francis Charles Christopher.
Goodwin, Donald John.
Grove, James Arthur.
Harkin, Michael Edward.
Hastings, Joseph William.
Helsby, Charles Michael.
Hilleard, Walter.
Holden, Terence Lancelot.
Hunt, John.
Jones, Alan George.
Khan, Imam Haqqari.
Laing, John Cranston.
Latchem, Michael Ronald.
Lawton, Derek.
Lee, Jack.
Mattis, Oswald Canute.
Mitra, Ramgopal.
Nougher, John.
Patel, Purushottam F.
Readhead, Winn.
Rees, Allan Edward.
Sahgal, Ravinder Kumar.
Schaller, Brian G. A.
Shalders, Michael Bloy.
Sharpe, Norman Renshaw.
Smith, Victor Francis Henry.
Speakman, Alan.
Stafford, Ronald.
Thompson, Geoffrey.
Tingle, George Barry.
Walker, Donald Geoffrey.
Wilcock, Anthony Lewis.
Williams, Michael Anthony.
Wiltshire, Dennis Edward.
Woodmancy, Miss Mary Catherine.

Associate-Membership Examination

Abbott, Samuel Louis.
Abrahams, Frank Dudley.
Advani, Tolaram Ramchand.
Alcock, Donald Geoffrey.
Alexander, George.
Allington, Reginald Arthur.
Angel, Basil Alfred.
Ayres, Michael Walter David.
Banerjee, Nripesh Chandra.
Batchelor, Robert Charles.
Beavington, Jack William.
Behnke, Jozef.
Bell, Brian Joseph.
Beveridge, Andrew.
Bhattacharyya, Asish Kumar.
Biss, Russell George.
Blanchard, John Clifford.
Bradbury, Barry James.
Bromige, Keith Bernard.
Brunt, John David.
Buckton, Geoffrey.
Burcham, Donald George.
Burt, Ronald Francis.
Carter, Raymond Fred Sidney.
Chadd, Peter Thomas.
Chan Boon Teik.
Cleavely, Albert Alexander.
Cockain, Roy Mason.
Condliffe, Sydney John.
Connelly, Terence Joseph.
Cook, David Allen.
Corp, Roy.
Crawford, Robert Sinclair.
Creber, Allen Lindsay.
Crewe, Leslie Walter.
Critten, Duncan Robin.
Daines, Alfred Lionel.
Datta, Shubhendra Kumar.
Docherty, David Gray.
Dunn, Horace William James.
Dutta-Munsi, Tushar Kanti.
Dykes, Alexander Robert.
Ettinger, Norman Barry.
Evans, Derek Norman.
Fallon, Michael John.
Feely, Brian.
Fitzgerald, Gerald John.
Gabrielczyk, Ryszard January.
Garbutt, Alan Watson.
Green, Louis.
Greenham, Ronald Gilbert.
Hansed, Jack.
Hares, Malcolm John Edmund.
Harrison, Arthur.
Hawkes, Cyril Dickson.
Heighington, Peter Dennis.
Hinshelwood, William Hutton.
Hodgson, Francis Torrens.
Holdman, Roy.
Holmes, Roger.
Homer, Albert Leslie.
Hood, Derek Edward.
Hughes, Brian Devine.
Hussain, Syed Rafat.
Jacobson, Frederick S. B.
James, Glyn Evans.
Janeway, Donald Alexander.
Johns, Michael Robert.
Jones, Kenneth Stuart Leslie.
Jones, Malcolm.
Jones, Robert Nicholas Copeland.
Julian, Leonard William.
Kanjee, Sadrooden A. A.
Kearns, Lawrence.
Kettlewell, Derek Harold.
Kowalski, Tadeusz Gabriel.
Kretsis, Kleomenis.
Kroie, Albert.
Leach, Bernard Arthur.
Lefever, Frederick Arthur.
Leggatt, Alec James.
Leung, Bernard.
Leung Ting-Kui.
Longrigg, Thomas Derek.
Luxton, Trevor Francis.
McIntyre, Douglas Arthur.
McKenzie, Alexander Stuart.
Magasiner, Alexander Sascha.
Marriage, Eric Francis.
Martin, John Neville.
Meads, John Richard.
Mears, Terence Frederick.
Mornement, Peter Clews.
Mukhopadhyay, Paritosh Kumar.
Murray, Colin Granville.
Njoku, Richard Alozieuwa.
Oke, Abraham A.
Ostoja-Kotkowski, M. Z. S.
Owen, Peter James.
Patel, Babubhai Shanabhai.
Patel, Jayant.
Patel, Purushottam Fulabhai.
Pengilly, Aubrey Herbert.
Pingle, Menash Moses.
Pitt, Peter Hubert.
Ready, Reginald Frederick.
Rees, Ronald Sterling Lloyd.
Rennie, Douglas Yorke.
Rice, Christopher John.
Rider, Brian Leonard.
Rowe, Kenneth John.
Scanes, Michael Boyce.
Scott, John Rodger.
Shaw, Douglas Perston.
Shaw, Kenneth William.
Short, John.
Simmonds, Stanley Bryan.
Smith, Graham John.
Smith, Wilfred Collier.
Snaddon, Robert Angus Anderson.
Sowerby, Arthur David.
Stone, Eric.
Storey, John Douglas.
Street, William Raymond.
Sutton, Benjamin Herbert Charles.
Swaden, Thomas Belcher.
Swan, Francis William Frederick.
Taylor, Ernest Edward Fred.
Taylor, Thomas Aelred.
Thomas, Martyn Robin Haden.
Timson, David John.
Tompkins, David Edward Alfred.
Van Straten, Frederik Willem Rudolf.
Vides, Leslie.
Ward, Leonard Charles.
Watling, Anthony John.
Weatherley, Noel.
Whitworth, Victor Percy.
Williams, Kenneth Wilfred.
Williamson, Norman William.
Wilson, Leslie Owen.

WILSON, Stanley Gordon.
WINTER, George Brian.
WOOLFALL, William Arthur.
WOOLLARD, Malcolm William Thomas.
WYSPIANSKI, Kazimierz Marien.
YAP CHIN LEONG.
YATES, William Eric.

EXAMINATIONS, JANUARY, 1958

The Examinations of the Institution will next be held in the United Kingdom and Overseas on Tuesday and Wednesday, January 7th and 8th, 1958 (Graduateship) and January 9th and 10th (Associate-Membership).

MACLACHLAN LECTURE COMPETITION, 1958

The closing date for the receipt of entries for the next Maclachlan Lecture Competition is Monday, March 31st, 1958. The general conditions of the competition are as follows :

1. The Institution of Structural Engineers shall institute a written lecture to be known as the Maclachlan Lecture and to be held annually.

2. The subject of the Lecture may be on any aspect of Structural Engineering as long as in every second year the subject shall be confined to steel structures.

3. Entrance into the competition for the Lecture shall be confined to Graduates and Associate-Members of the Institution who are under the age of 32 years.

4. All papers entered for the competition shall be submitted to assessors to be appointed by the Council of the Institution, and all such papers (including the prize-winning Lecture) shall be available for publication in the Journal of the Institution at the discretion of the Council.

5. No paper submitted shall have been published or read elsewhere.

6. The winner of the competition shall be required to present the Lecture to a meeting of the Institution at which he will be presented with the sum of £17 10s.

7. Should a competitor's paper be considered worthy of ranking second in merit he will receive a consolation award of £5.

8. In the event of there being no winner of the competition in any one or more years, whether because no lecture submitted is considered to be of sufficient merit to warrant award or for any other reason, the Institution shall transfer the above sums to the Research Fund of the Institution.

Particulars of the Competition for 1958

1. The Maclachlan Lecture will be given at a meeting of the Institution to be arranged towards the end of 1958.

2. The subject of the Lecture may be on any aspect of Structural Engineering.

3. The work should be submitted as the script of a lecture which the Author, if successful in the competition, will deliver before an audience in the course of about one hour. The development of mathematical formulae and detailed calculations should be avoided as far as possible in the text ; if they are essential they should be embodied in appendices. Photographs, drawings, graphs, etc., which would appear as illustrations to the lecture in published form, should accompany the script. If additional illustrations would be shown as slides, a list of these should be included.

4. Six copies of each lecture should be submitted and should be addressed to the Secretary of the Institution.

5. The closing date for the receipt of entries by the Institution is Monday, March 31st, 1958.

LONDON GRADUATES' AND STUDENTS' SECTION

The following meetings will be held at 11, Upper Belgrave Street, London, S.W.1, at 6.30 p.m.

Monday, November 18*th*, 1957

A talk on " The Forth Bridge " will be given by Mr. J. K. Anderson, M.A., M.I.C.E.

Tuesday, December 10*th*, 1957

Papers will be read by members of the Section.

Tuesday, January 28*th*, 1958

An Address will be given by a Vice-President of the Institution.

Hon. Secretary : A. S. Beeson, 28, Arnold Crescent, Whitton Dene, Isleworth, Middlesex.

BRANCH NOTICES

LANCASHIRE AND CHESHIRE BRANCH

The following meetings have been arranged :—

Monday, November 11*th*, 1957

Mr. G. B. Godfrey, A.M.I.Struct.E., A.M.I.C.E., A.M.I.Mun.E. (Associate-Member of Council) on " Steel Tubes and Hollow Sections."

Monday, December 16*th*, 1957

Mr. S. Richards, A.M.I.Struct.E., and Mr. N. Lancaster will give a paper—" A Review of the Structural Steelwork in the 'Seraphim' Extensions at Appleby-Frodingham."

Tuesday, January 7*th*, 1958

Mr. E. Ll. Morgan, M.Sc.(Tech.), A.M.I.Struct.E., A.M.I.Mun.E., on " Shrinkage in Soils."

The above meetings will take place at the College of Science and Technology, Manchester, at 6.30 p.m. (preceded by light refreshments).

Merseyside Panel

A meeting will be held at the Liverpool Engineering Society, Dale Street, Liverpool, on Tuesday, November 12th, 1957, when Mr. G. B. Godfrey, A.M.I.Struct.E., A.M.I.C.E., A.M.I.Mun.E. (Associate-Member of Council) will give a paper on " Steel Tubes and Hollow Sections." The meeting will commence at 6.45 p.m. and light refreshments will be available from 6 p.m.

Joint Hon. Secretaries : J. L. Robinson, A.M.I.Struct.E., 314, Northenden Road, Sale, Manchester. M. D. Woods, A.M.I.Struct.E., 58, Spring Gardens, Salford, 6.

MIDLAND COUNTIES BRANCH

The following meetings have been arranged :—

Wednesday, November 13*th*, 1957

Mr. F. I. Lees, B.Sc.(Eng.), on " The Fabrication and Erection of Pelham Bridge, Lincoln." At the Electricity Demonstration Hall, Irongate, Derby, at 6.15 p.m.

Friday, November 22nd, 1957

Mr. H. C. Husband, B.Eng., M.I.Struct.E., M.I.C.E., M.I.Mech.E. (Honorary Curator) and Mr. K. H. Best, B.Eng., M.I.Struct.E., A.M.I.C.E., on " Some Recent Highway Bridges in Ceylon." At the James Watt Memorial Institute, Great Charles Street, Birmingham, at 6 p.m.

Friday, January 24th, 1958

Mr. F. M. Bowen, M.I.Struct.E., M.I.C.E., Assoc.I.Mech.E. (Member of Council) and Mr. B. E. S. Ranger, A.M.I.Struct.E., A.M.I.C.E. (Associate-Member of Council) on " Steelwork in Transit Shed 102, Southampton Docks." At the James Watt Memorial Institute, Birmingham, at 6 p.m.

Hon. Secretary : J. R. Chaffer, M.I.Struct.E., 107, Jockey Road, Sutton Coldfield, Warwickshire.

GRADUATES' AND STUDENTS' SECTION

The following meetings have been arranged :—

Friday, November 1st, 1957

Mr. L. G. Booth, Ph.D., M.A., on " Structural Use of Timber."

Friday, December 6th, 1957

Joint Meeting with the Junior Section of the Institution of Municipal Engineers. Mr. W. J. Young, B.A.I., on " The Cement Gun and its Use in the General Field of Structural Engineering."

The above meetings will be held at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, at 6.30 p.m.

Hon. Secretary : F. A. Butterworth, " Roscrea," Tansey Green, Pensnett, Brierley Hill, Staffs.

NORTHERN COUNTIES BRANCH

The following meetings have been arranged :—

Thursday, November 7th, 1957

Joint Meeting with the Northern Architectural Association. Mr. E. Shepley, B.Sc., M.I.C.E., on " Choice of Structure." At Middlesbrough.

Wednesday, November 20th, 1957

Joint Management Meeting at which a lecture will be given by Mr. Peter G. Masefield. At Middlesbrough.

Thursday, November 21st, 1957

Joint Management Meeting at which a lecture will be given by Sir F. C. Hooper. At the Connaught Hall, Blackett Street, Newcastle.

Tuesday, December 3rd, 1957

Mr. F. M. Bowen, M.I.Struct.E., M.I.C.E., Assoc.I.Mech.E. (Member of Council) and Mr. B. E. S. Ranger, A.M.I.Struct.E., A.M.I.C.E. (Associate-Member of Council) on " Steelwork in Transit Shed 102, Southampton Docks." At Middlesbrough.

Wednesday, December 4th, 1957

The above paper will be repeated in Newcastle.

Wednesday, January 15th, 1958

Joint Meeting with the Institution of Civil Engineers. Mr. J. O. C. Ritchie, T.D., on " Water Towers." At Middlesbrough.

Thursday, January 16th, 1958

Joint Meeting with the Northern Architectural Association at Higham Place, Newcastle. Details to be announced.

Meetings in Middlesbrough will be held in the Cleveland Scientific and Technical Institution ; meetings in Newcastle, except where otherwise stated, in the Neville Hall. All meetings commence at 6.30 p.m., preceded by buffet tea at 6 p.m.

Hon. Secretary : H. W. Dowe, A.M.I.Struct.E., 143, Laburnum Road, Redcar, Yorks.

NORTHERN IRELAND BRANCH

The following meetings have been arranged :—

Tuesday, November 5th, 1957

Mr. J. W. A. Ager, A.M.I.C.E., on " A New Form of Light-Weight Concrete," accompanied by a film. An opportunity will be given for discussion. At the College of Technology, Belfast, commencing at 6.45 p.m., preceded by tea.

Monday, December 9th, 1957

Meeting with the Northern Ireland Association of the Institution of Civil Engineers. Professor J. L. Montrose on " The Interpretation of Contracts and Arbitration." At Queen's University, Belfast.

Tuesday, January 7th, 1958

Meeting to be arranged.

Hon. Secretary : A. H. K. Roberts, B.A., B.A.I., M.I.Struct.E., M.I.C.E.I., A.M.I.C.E., " Barbizon," 26, Dunlambert Park, Belfast.

SCOTTISH BRANCH

The following meetings have been arranged :—

Tuesday, November 5th, 1957

Mr. F. M. Bowen, M.I.Struct.E., M.I.C.E., Assoc.I.Mech.E. (Member of Council) on " Steelwork in Transit Shed 102, Southampton Docks." At the Adelphi Hotel, Coburn Street, Edinburgh, 6.15 p.m.

Wednesday, November 20th, 1957

Joint Meeting with the West of Scotland Branch of the Institute of Welding. Mr. J. A. Forrest, A.M.I.Mech.E., and Mr. James McLean, B.Sc., on " Fabrication, Erection and Welding Dounreay Sphere." At the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, at 7 p.m.

Tuesday, December 10th, 1957

Mr. O. A. Kerensky, B.Sc., M.I.Struct.E., M.I.C.E., on " Design of Plate Girders." At the Institution of Engineers and Shipbuilders, Glasgow, at 7 p.m.

Tuesday, January 21st, 1958

Mr. P. Russell, B.Sc., A.M.I.C.E., M.Inst.H.E., on " Recent Concrete Construction in Scotland."

Hon. Secretary : W. G. Cantlay, B.Sc.(Eng.), A.M.I.Struct.E., A.M.I.C.E., 3, Blairbeth Terrace, Burnside, Glasgow.

SOUTH WESTERN COUNTIES BRANCH

The following meetings have been arranged :—

Friday, November 1st, 1957

Chairman's Address by Mr. E. W. Howells, M.I.Struct.E. The President and Secretary of the Institution will attend the meeting, which will be followed by an informal Dinner. At the Duke of Cornwall Hotel, Plymouth, 7 p.m.

Friday, December 6th, 1957

Mr. Clifford E. Saunders, M.I.Struct.E., A.M.Inst.W., on " Some Unusual Structural Engineering Problems." At the Duke of Cornwall Hotel, Plymouth, 6 p.m. (Tea will be served at 5.30 p.m.)

Friday, January 17th, 1958

Joint meeting with the local branch of the Institution of Civil Engineers. Mr. W. R. Hockaday, M.I.C.E., on " Lifting Equipment." At the Duke of Cornwall Hotel, Plymouth, 6 p.m. (Tea will be served at 5.30 p.m.)

Hon. Secretary : C. J. Woodrow, J.P., " Elstow," Hartley Park Villas, Mannamead, Plymouth, Devon.

WALES AND MONMOUTHSHIRE BRANCH

The following meetings have been arranged :—

Tuesday, November 5th, 1957

Chairman's Address, " Safety in Construction " by Mr. G. R. Brueton, M.I.Struct.E., A.M.I.C.E., followed by a discussion. At the South Wales Institute of Engineers, Park Place, Cardiff, at 6.30 p.m.

Saturday, November 9th, 1957

At the County Buildings, Colwyn Bay, 6 p.m. The Chairman's Address will be repeated and will be followed by a discussion.

Tuesday, December 3rd, 1957

Joint meeting with the Institute of Welding. Mr. A. V. Hooker, M.I.Struct.E., M.I.C.E. (Past Chairman), " Recent Thoughts on Structural Welding." At the South Wales Institute of Engineers, Cardiff, 6.30 p.m.

Wednesday, December 11th, 1957

Joint meeting with the Institution of Civil Engineers. At the Mackworth Hotel, Swansea. Details to be announced.

Wednesday, January 15th, 1958

Mr. E. M. Lewis, A.C.G.I., A.M.I.W. on " Some Notes on the Use of High Pre-Load Bolts in the United Kingdom." At the Mackworth Hotel, Swansea, at 6.30 p.m.

Hon. Secretary : K. J. Stewart, A.M.I.Struct.E., A.M.I.C.E., 15, Glanmor Road, Swansea.

WESTERN COUNTIES BRANCH

The following meetings have been arranged :—

Friday, November 1st, 1957

Combined Meeting with the Institution of Civil Engineers. Mr. J. H. G. King, A.M.I.Struct.E., A.M.I.C.E., on " A Guide to Foundation Problems through Geology."

Friday, November 15th, 1957

Three papers to be given for the special interest of the junior members : Mr. H. G. Gooding, A.R.I.C.S., on " Final Accounts " ; Miss M. Woodmancy (Student) on " Trends in Modern Architecture " ; Mr. R. Purnell (Graduate) on " Precast Concrete Construction."

Friday, December 6th, 1957

Mr. R. G. Taylor, B.Sc.(Eng.), M.I.Struct.E., A.M.I.C.E., on " Tubular Structures."

Friday, January 3rd, 1958

Mr. G. B. Smedley, B.Sc.(Tech.), A.M.I.Struct.E., A.M.I.C.E., on " Construction of a Prestressed Concrete Circular Tank." The above meetings will be held in the Small Lecture Theatre, University Engineering Laboratories, University of Bristol, at 6 p.m., preceded by tea at 5.30 p.m.

Hon. Secretary : E. Hughes, M.I.Struct.E., 23, Southdown Road, Westbury-on-Trym, Bristol, 9.

YORKSHIRE BRANCH

The following meetings have been arranged :—

Wednesday, November 20th, 1957

Joint Meeting with the Yorkshire Association of the Institution of Civil Engineers. Mr. H. C. Husband, B.Eng., M.I.Struct.E., M.I.C.E., M.I.Mech.E. (Hon. Curator) and Mr. K. H. Best, B.Eng., M.I.Struct.E., A.M.I.C.E., on " Recent Highway Bridge Construction in Ceylon." At Leeds.

Wednesday, December 11th, 1957

Mr. G. B. Godfrey, A.M.I.Struct.E., A.M.I.C.E., A.M.I.Mun.E. (Associate-Member of Council) on " Post-War Developments in German Steel Bridges and Structures." At Leeds.

Thursday, December 12th, 1957

The above meeting will be repeated at Sheffield.

Wednesday, January 15th, 1958

Mr. D. Beckett, B.Sc.(Eng.), Grad.I.C.E., and Mr. B. J. S. Walls, B.Sc.(Eng.), Grad.I.C.E., on " An Introduction to Pre-Stressed Concrete in Highway Engineering." At Leeds.

Meetings at Leeds will be held at the Central Electricity Authority Offices, Whitehall Road, at 6.30 p.m.

Meetings at Sheffield will be held at the Royal Victoria Hotel, at 6.30 p.m.

Hon. Secretary : W. B. Stock, A.M.I.Struct.E., 34, Hobart Road, Dewsbury, Yorks.

UNION OF SOUTH AFRICA BRANCH

Hon. Secretary : A. E. Tait, B.Sc., A.M.I.Struct.E., A.M.I.C.E., P.O. Box 3306, Johannesburg, South Africa.

During weekdays Mr. Tait can be contacted in the City Engineer's Department, Town Hall, Johannesburg. Phone 34-1111, Ext. 257.

Natal Section Hon. Secretary : J. C. Panton, A.M.I.Struct.E., A.M.I.C.E., c/o Dorman Long (Africa) Ltd., P.O. Box 932, Durban.

Cape Section Hon. Secretary : R. F. Norris, A.M.I.Struct.E., African Guarantee Building, 8, St. George's Street, Cape Town.

EAST AFRICAN SECTION

Chairman : R. A. Sutcliffe, M.I.Struct.E.

Hon. Secretary : K. C. Davey, A.M.I.Struct.E., P.O. Box 30079, Nairobi, Kenya.

SINGAPORE AND FEDERATION OF MALAYA SECTION

Chairman : T. Karmakar, M.I.Struct.E.

Hon. Secretary : W. N. Cursiter, B.Sc., A.M.I.Struct.E., c/o Redpath Brown and Co. Ltd., P.O. Box 648, Singapore.

ADDITIONS TO THE LIBRARY

A.S.T.M. PROCEEDINGS, Vol. 56, 1956, Philadelphia, 1957.

BRITISH PETROLEUM EQUIPMENT, 1957/58 Ed., London, 1957.

CEMENT AND CONCRETE ASSOCIATION. Library Translation No. 63, *Theory of the Deformation and the Failure of Concrete*, by E. Reinius ; Library Abstracts No. 6, *Building Methods in Eastern Europe*, by M. Y. Saillard.

Technical Reports :

TRA/251. *Instituto Sperimentale Modelli e Strutture, Bergamo, Italy*, by R. E. Rowe.

TRA/252. *Recent Advances in the Study of Shells in Great Britain*, by P. B. Morice.

TRA/266. *The Effect of Mix Proportions and Testing Conditions on Drying Shrinkage and Moisture Movement of Concrete*, by B. W. Shacklock and P. W. Keene.

TRB/249. *A Review of Current Problems on the Durability of Concrete*, by J. D. McIntosh, London, 1957.

EWING, W. M., JARDETZKY, W. S. and PRESS, F. *Elastic Waves in Layered Media*, New York and London, 1957. Presented by Mr. F. D. C. Henry.

FAGG, S. V. *Differential Equations*, London, 1956. Presented by Mr. H. W. Coultas.

Federation of Civil Engineering Contractors Handbook, 1957-58, London, 1957.

FULTON, F. S. *Concrete Technology*, A South African Handbook, Johannesburg, 1957. Presented by the Author.

GEDDES, S. *Building and Public Works Administration, Estimating and Costing for the use of Civil Engineers, Surveyors and Building Contractors*, 5th Ed., London, 1957.

HAAIJER, G. *Plate Buckling in the Strain-Hardening Range*, Lehigh University, U.S.A., 1957.

HALASZ, R. VON (Editor). *Holzbau-Taschenbuch*, 5th Ed., Berlin, 1957.

HETENYI, M. *Beams on Elastic Foundation. Theory with Applications in the Fields of Civil and Mechanical Engineering*, Michigan, 1946. Presented by Mr. K. M. Strauss.

HEYMAN, J. *Plastic Design of Portal Frames*, Cambridge, 1957. Presented by Mr. F. A. Partridge.

Hiduminium Technical Data, Slough, Bucks, High Duty Alloys Ltd., 1956.

I.C.I. Engineering Codes and Regulations, Group C (Electrical), Vol. I.I. *Statutory and other Rules, Regulations and Codes*, London. Royal Society for the Prevention of Accidents, Industrial Safety Division, 1957.

International Association for Bridge and Structural Engineering, Preliminary Publication of the 5th Congress, 1956, Lisbon, 1956.

KOHL, E. *Praktische Winke zum Studium der Statik*, Berlin, 1957. Presented by Dr. E. H. Bateman.

KRENZ, A., and OSTERLOH, H. *Klothoiden-Taschenbuch für Entwurf und Absteckung*, Weisbaden, 1956.

LEA, F. M. *The Chemistry of Cement and Concrete* (Revised Edition of Lea and Desch), London, 1957. Presented by Mr. W. H. Woodcock.

MAXWELL-COOK, J. C. *Reinforced Concrete*, London, 1957. Presented by the Author.

NYLANDER, H. and PETTERSSON, O. *Festskrift till Professor Carl Forssell*, Stockholm, 1956.

PRITCHARD, A. B. *Oil-Fired Central Heating*, London, 1957.

REYNOLDS, C. E. *Reinforced Concrete Designer's Handbook*, 5th Edition, London, 1957.

ROMANOFF, M. *Underground Corrosion*, Washington, 1957.

RYDER, G. H. *Strength of Materials : A Text-Book for Degree Students*, 2nd Ed., London, 1957.

STEEL, R. *The Rent Act*, 1957, London, 1957.

Technical University of Constructional Engineering and Transport, Hungary. Papers read at the Scientific Session, November, 1955, Budapest, 1957. (In Hungarian, with short summary in English.)

University of Illinois Engineering Experiment Station Bulletins :

No. 442. *Distribution of Air within a Room for Year-Round Air Conditioning, Part II*, by H. E. Straub and M. M. Chen.

No. 443. *Snap-Through and Post-Buckling Behaviour of Cylindrical Shells under the Action of External Pressure*, by H. L. Langhaar and A. P. Boresi.

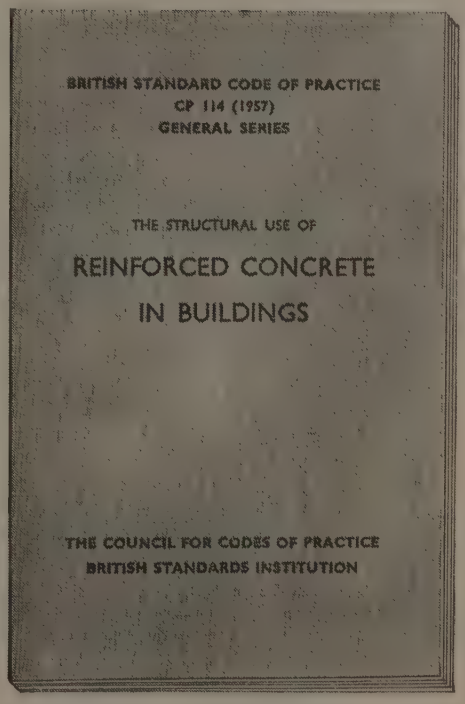
WEIDLINGER, P. *Aluminium in Modern Architecture*, Vol. II—*Engineering Design and Details*, New York and London, 1956.

TENTOR

REGISTERED TRADE MARK

and CP114 (1957)

Changes in the 1957 Edition of the British Standard Code of Practice CP114, make the use of the Tentor Bar, with its high tensile and bond strength, an even more attractive proposition.



You can now make greater use of the high strength of Tentor Bar and also obtain additional savings.

For instance, the maximum *tensile* stress for Tentor Bars is now *30,000* lbs./sq.in. giving *a saving of 15%* of the cost of mild steel rounds. Again, the maximum *compressive* stress is now *23,000* lbs./sq.in. giving a cost for Tentor still generally less than that for mild steel bars.

Bond stresses are also raised and a more economical design method described.

An information sheet detailing the changes is obtainable on request and revised editions of our literature will be available shortly.

The efficient Tentor service is at your disposal and enquiries are welcomed.

Tentor is manufactured by

Guest Keen & Nettlefolds (S. Wales) Ltd., Cardiff

McCall & Co. (Sheffield) Ltd., Templeborough, Sheffield;

The United Steel Companies Ltd., Sheffield.

The

TENTOR BAR

Company Limited

43 UPPER GROSVENOR STREET, LONDON W.1 · Tel: GRO 8101

Corby Grammar School Northants.

METAL WINDOWS & DOORS

MELLOWES & CO. LTD.

SHEFFIELD · LONDON · OLDHAM

Architect: A. N. Harris Esq., F.R.I.B.A., County Architect, Northants C. C.

Member of the Metal Window Association.

STENT

PRECAST CONCRETE PILES

Preferred by constructional engineers for their unchanging supremacy, Stent Precast Concrete Piles have proved their qualities wherever used.

AVAILABLE FOR IMMEDIATE DELIVERY

May we forward full details

STENT PRECAST CONCRETE LTD. Sales Office: 1, Victoria Street, London, S.W.1. Tel: Abbey 2573
Head Office & Works: Dagenham Dock, Essex. Tel: Rainham (Essex) 780

London contractors on partitioning job say:–

'No other material goes up as fast as Stramit!'

The smart appearance of the office of Max Rayner (Artwork) Ltd. owes much to its new, glazed Stramit partitions in 1-in. x 4-in. timber framing: the Stramit is held in position by quadrant moulds.

Messrs. Brooking Brothers, contractors, of London, recently erected Stramit partitions at the offices of Max Rayner (Artwork) Ltd. in Lexington Street, W.1. They stated that, in their opinion, no other material could go up at the speed with which they were able to erect Stramit partitions.

But speed is only a small part of the Stramit story. Stramit partitions are smart, as you can see from this picture. There is a notable absence of drumming, too, when Stramit is employed. And this material positively resists fire.

Stramit of standard grade takes paint and plaster direct. It is also available faced with hardboard, embossed aluminium or fabric (the last-named in a variety of attractive colours and designs).

WHAT IS STRAMIT?

Stramit is a low-cost, dry-construction material made of compressed straw. It combines great strength and rigidity with exceptional values of thermal insulation and sound reduction. And it positively resists fire.

Stramit is available in three grades. Standard grade (for ceilings, partitioning, factory screens, etc.) weighs approximately 3.8 lb./sq. ft. and costs from 9/- per sq. yd., including delivery.

Also available: Roofing grade (for roof-decking, wall-linings, etc.); Low-Density grade (for non-load-bearing thermal insulation) and a special asbestos-felt facing (to give a Class 1 rating for spread of flame).

STOCK SIZES: 4 ft. wide x 6, 8, 9, 10 & 12 ft. long.
Special sizes made to order.

AVAILABLE FROM LEADING MERCHANTS.

STRAMIT BOARDS LTD.
COWLEY PEACHEY, UXBRIDGE, MIDDX.
Telephone: West Drayton 3751

STRAMIT

THE TWO-INCH THICK

BUILDING SLABS

FILL THIS IN AND POST IT NOW!

Please send me full details of Stramit Slabs.

Name of firm.....

.....

Address .....

.....

For the attention of .....

Status ..... S.E.

IT'S HERE AT LAST !

The PORTABLE

DENISON

COMPRESSION TESTING MACHINE

for tests on concrete cubes, cylinders, etc

- *Ideally suitable for use on construction sites.*
- *Capacity 150 tons by increments of ¼ ton.*
- *Easily portable— weighs only 3½ cwt.*
- *Convenient controls including load pacer.*
- *Compact — less than 3 feet high.*

Write for further details now

SAML. DENISON & SON LTD

HUNSLET FOUNDRY · MOOR ROAD · LEEDS 10

Tel : Leeds 7-5488 Grams : 'Weigh Leeds 10'

Area Offices at

LONDON	BIRMINGHAM	NORTH-WEST	NORTH-EAST
SLOane 4628	Midland 3931	Blackfriars 1986	Leeds 2-8433

PIONEERS OF CAST IN SITU PILING

SIMPLEX PILES

SIMPLEX CONCRETE PILES LTD

25, BRECHIN PLACE, SOUTH KENSINGTON, S.W.7

Telephone: FREmantle 0035/6

LINCOLN ELECTRIC SERVES THE INDUSTRY OF THE WORLD 10

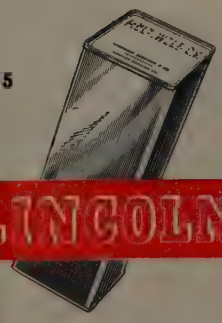
Thames Haven to Romford Pipeline

In constructing this 17-mile 24-inch welded steel pipeline for the North Thames Gas Board and Shell-Mex & B.P. Ltd., Messrs William Press & Son Ltd., are extensively using Lincoln Diesel Welding Units, Improved Fleetweld 5 and Improved Shield Arc 85 electrodes.

The agreement, that from mid-1958 Shell Haven Refinery will be transmitting to Romford 25 million therms of gas per year, largely depends on faultless pipework. The contracts call for the highest standard of welding, and ultrasonic testing is being used in conjunction with radiography by Messrs Metal and Pipeline Endurance Ltd. in their inspection and double-checking for weld quality.

The combination of Improved Fleetweld 5 and Improved Shield Arc 85 is being extensively used on all pipelines where the 'stove pipe' welding technique, high speeds and high mechanical joint efficiency are required.

IMPROVED BRITISH FLEETWELD 5



Improved Fleetweld 5 conforms to B.S. 639:1952, and is approved by Lloyd's Register of Shipping and the Ministry of Transport and Civil Aviation. It is also being used extensively in the expansion now taking place within the British Petroleum Industry, and the newly developing Petro-Chemical Industries.

LINCOLN

Largest manufacturers of D.C. Welders in the United Kingdom

LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 4581 (5 lines) 920 (5 lines)

. . . . Heard of

PEDATIFID

Foundations?—*the unique*

PYNFORD

method of

NEUTRALISING SUBSIDENCE

meet us at

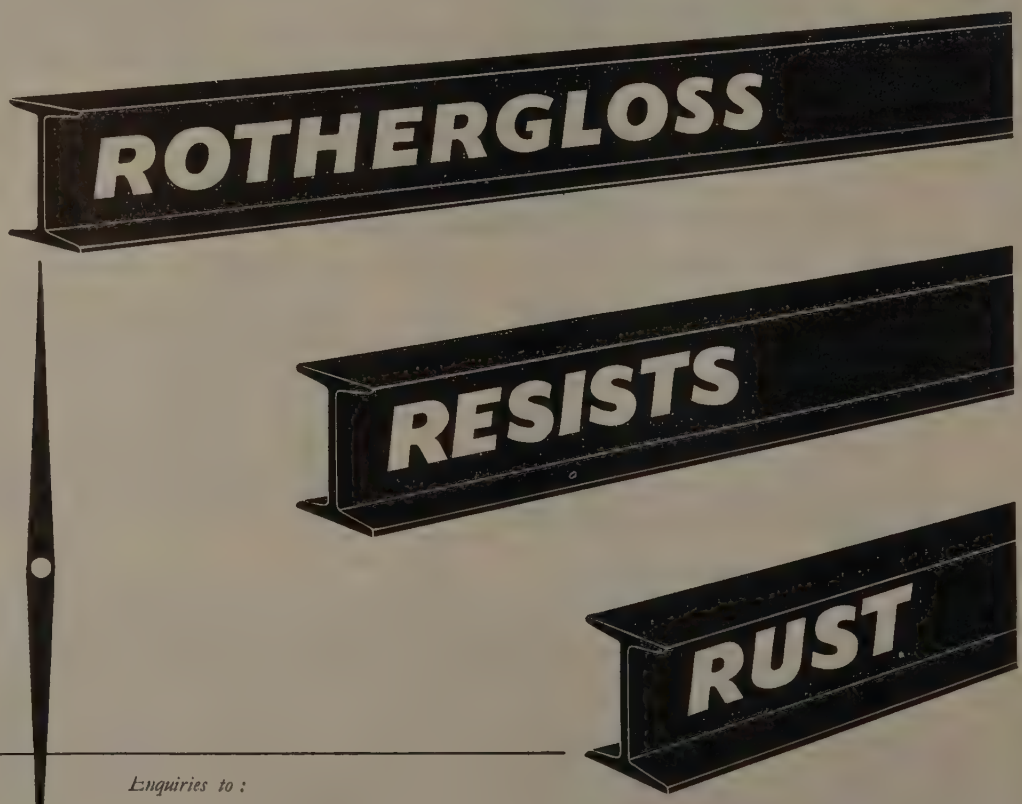
STAND 587

Grand Hall Gallery
Olympia during The
Building Exhibition
(Nov. 13th—27th)

where exhibits include Jacks, Jacking Apparatus, Underpinning Stools, Etc., and where we shall be pleased to advise on all foundation problems.

Pynford Limited
(Patentees) Foundation Engineers
74 LANCASTER ROAD
STROUD GREEN, LONDON, N.4
Tel : ARChway 6216/7

THE UNITED STEEL COMPANIES LTD

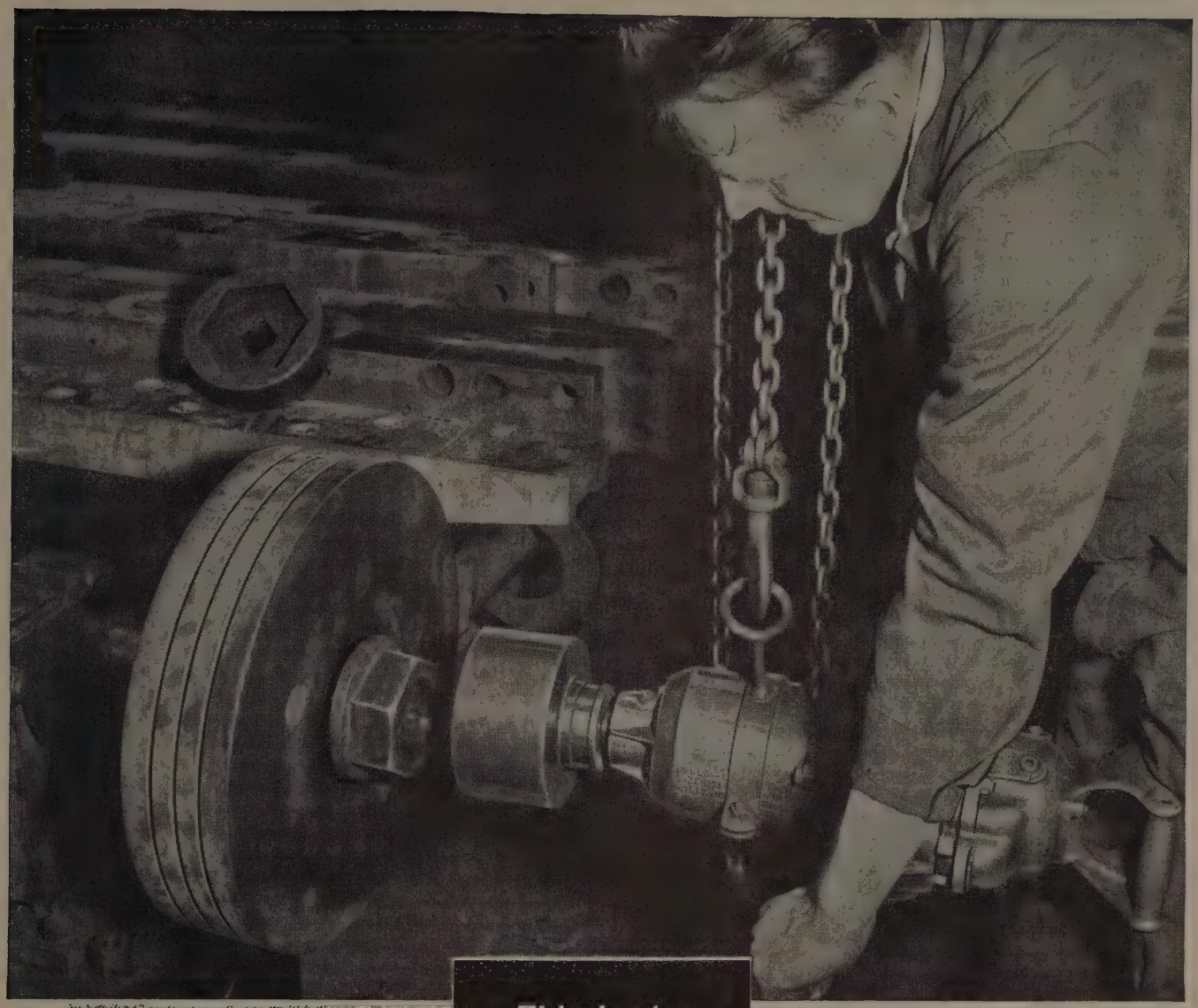


ROTHERGLOSS
BLACK RESIN PAINT
FOR PROTECTION OF
ALL STEELWORK

UCC
CHEMICALS FROM COAL

Enquiries to :

UNITED COKE AND CHEMICALS COMPANY LIMITED
(Sales Department 206), P.O. Box No. 136, Handsworth, Sheffield 13
Telephone : Sheffield 63025 Telegrams : ' Unichem,' Sheffield



This is the C.P. 375 IMPACT WRENCH

For bolts up to 1¾"

IT CUTS OPERATING TIME FROM MINUTES TO SECONDS

CONSOLIDATED PNEUMATIC MAKE OVER 480 DIFFERENT MODELS OF POWER TOOLS

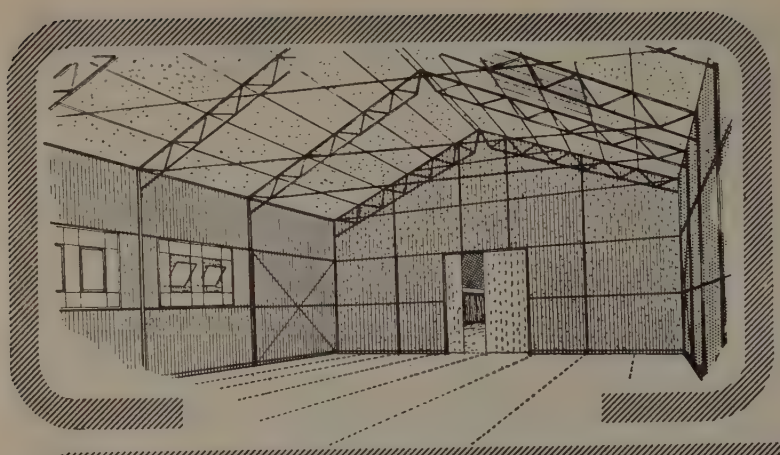
Whether running up ¼" nuts in thousands on light assembly or driving 1¾" nuts on heavy construction work, there's a C.P. pneumatic Impact Wrench to drastically reduce the time and costs of the job. The patented impact clutch eliminates torque reaction and the final torque obtained can be accurately controlled by pressure regulation. There's no twisting thrust or kickback when nuts are fully seated. To this speed and efficiency, then add versatility. C.P. Impact Wrenches are available in 6 sizes and can also be used for tapping, stud-setting, screwdriving, drilling or reaming. Ask for the Impact Wrench section of Catalogue No. 50.

Consolidated Pneumatic

CONSOLIDATED PNEUMATIC TOOL CO., LTD., 232 DAWES ROAD, LONDON, S.W.6.

AIR COMPRESSORS · PNEUMATIC TOOLS · ELECTRIC TOOLS · CONTRACTORS EQUIPMENT · ROCK DRILLS · PUMPS · DIAMOND DRILLS

CP106



'Blaby' Prefabricated Steel Structures are available in single or multiple spans, with doors, windows, roof lights, etc., as required. Standard 'Blaby' Structures 100 ft. x 45 ft. wide complete with sliding doors and windows, available from stock.

Our Structural Sales Dept. will forward further information and FREE brochure on request.

WORKS: CIRCLE WORKS, GLEN HILLS, LEICESTER

Foundation and erection costs considerably reduced by specifying 'Blaby' Structures: Unique design integrates traditional Hot Rolled Mild Steel sections with Cold Formed Steel sections, giving increased strength/weight ratio: resistance to atmospheric corrosion of Cold Formed sections four to six times that of Mild Steel.

B 'Blaby' Prefabricated Structures

Designed and Manufactured by:— **J. E. LESSER & SONS LTD.**

HOUnslow 7281/7
Green Lane, Hounslow, Middlesex

TEST BORINGS

FOR THE UNDERLYING TRUTH

To ensure
THE STABILITY OF FOUNDATIONS AND EARTH WORKS

OBTAIN RELIABLE INFORMATION OF GROUND CONDITIONS

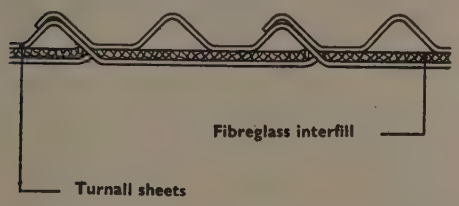
- GEOPHYSICAL SURVEYS
- SOIL SAMPLING & TESTING
- REPORTS ON GROUND CONDITIONS

GROUND EXPLORATIONS LTD
75 UXBRIDGE ROAD, EALING, W.5
Phones: EALing 1145/6 and 9251/2

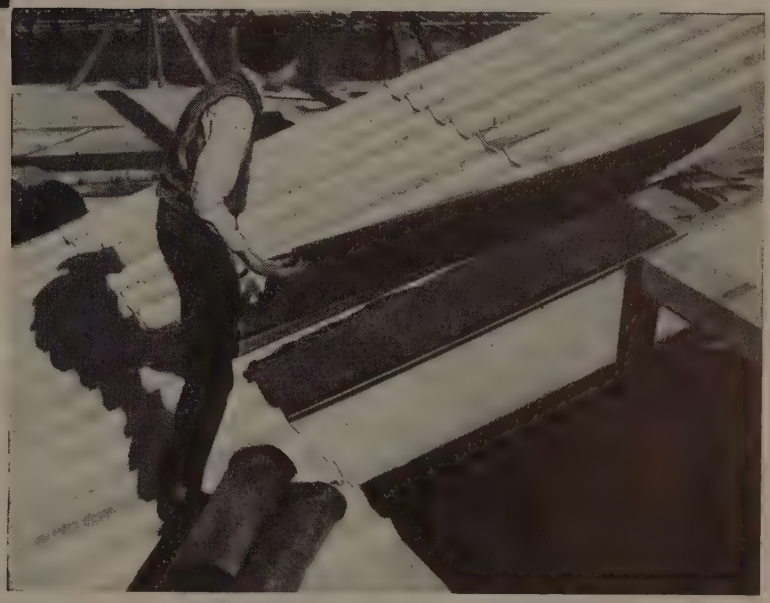
TWO ROOFS THAT INSULATE!

Putting in the insulation as you put up the roof is plain economic sense. With the high insulating efficiency, permanence and fire resistance of Fibreglass filling, the sandwich construction is a practical method in almost every situation.

TURNALL COMBINED SHEETS— an interlocking form of double-skin construction in one operation— is improved by ½″ Fibreglass interfill inserted in the cavity.



TURNERS ASBESTOS CEMENT CO. LTD.



THE UNIVERSAL STANDARD SIX CONSTRUCTION consists of 1″ Bitumen Bonded Fibreglass between sheets of asbestos cement cladding.

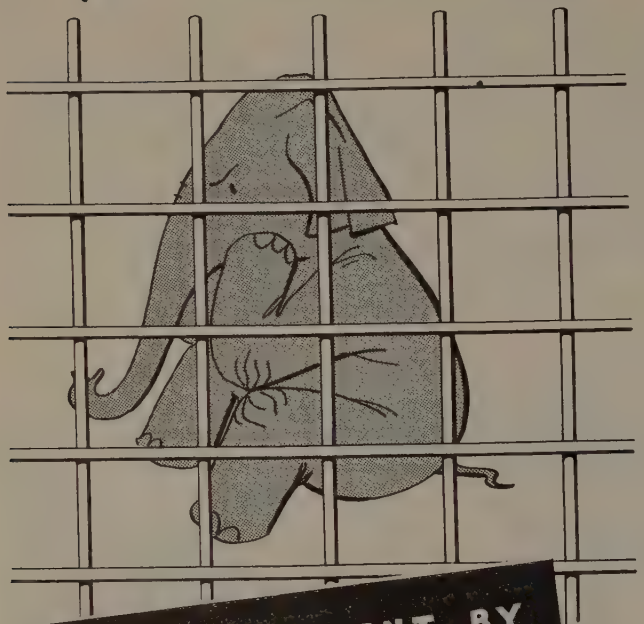
THE UNIVERSAL ASBESTOS MANUFACTURING CO., LTD.

FIBREGLASS TRADE MARK

details from

FIBREGLASS LIMITED, ST. HELENS, LANCS · ST. HELENS 4224

You cannot forget..

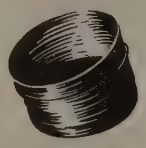


REINFORCEMENT BY McCALLS

REINFORCEMENT

'MATOBAR' WELDED FABRIC

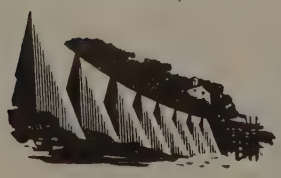
We scarcely need remind you that McCalls provide reinforcement in the form best suited to the needs of the job—'Matobar' Welded Fabric, shaped bars, helical coils, etc.



McCALL & CO. (Sheffield) LTD.

PRESTRESSING STEEL

McCALLS "MACALLOY"



High Tensile Steel Bars of $\frac{3}{4}$" to $1\frac{1}{8}$" diameter for prestressed concrete construction using the Lee-McCall System.

McCALLS MACALLOY LIMITED

Write for "Reinforcement by McCalls" for full information

TEMPLEBOROUGH · SHEFFIELD · P.O. Box 41

Telephone : ROTHERHAM 2076 (P.B. Ex. 8 Lines)

LONDON OFFICE :
8-10 Grosvenor Gardens, S.W.1 - Tel. SLOane 0428

BIRMINGHAM OFFICE :
83 Kineton Green Road, Olton, Solihull - Tel. Acocks Green 0229

PORTSMOUTH OFFICE :
23 and 25 Spur Road, Cosham - Tel. Cosham 78702

M2

COMPLETE SITE INVESTIGATION

Field Tests . Soil Sampling and Analysis

The service provided jointly by Pre-Piling Surveys and Duke & Ockenden covers the whole field of site investigation and ground testing.

The unique Pre-Piling deep penetration tests yield a continuous record of the variations in bearing value and character of strata. All cavities and pockets are exactly located.

Duke & Ockenden are specialists in boring for all purposes, soil sampling for laboratory analysis and the provision of full geological reports. Their DANDO cable percussion and rotary drilling equipment is well known in all parts of the world. We are confident that architects, engineers and surveyors will find in this co-operative service an unequalled source of systematic, exhaustive survey, accurate data, adaptability and economy.

PRE-PILING SURVEYS LTD

SURVEYS

Tel. ABBey 4925

DUKE & OCKENDEN LTD.

DANDO

Tel. ABBey 6338

1 VICTORIA STREET, WESTMINSTER, S.W.1

Works: Ferry Wharf, Littlehampton. *Tel.:* Littlehampton 6

Contractors to the Admiralty, War Office, Air Ministry, Crown Agents, British Railways, Public Works Authorities

YORKSHIRE HENNEBIQUE

Contracting Co. Ltd.

ESTABLISHED 1904

CIVIL ENGINEERING CONTRACTORS

HEAD OFFICE:
HENNEBIQUE HOUSE
The Mount · York
Telephone: YORK 54656 (4 *lines*)

Branch Offices:

HULL: 30 WINCOMLEE. Telephone: Hull 33501.
LEEDS: ROYDS WORKS, LOWER WORTLEY, LEEDS 12. Telephone: Leeds 637891.

All Electric Girder Type Radial Drilling Machine with centralised control. Five sizes 4′ to 8′. 4 speeds, range 160 to 600 r.p.m. 3 feeds. Capacity up to 2″ from solid in mild steel. Also made with 8 speeds and 3 feeds and single speed and feed.

TOWN E.G.4.

girder type radial drilling machine

Write for descriptive leaflet on the above machines.

FREDK. TOWN & SONS LTD.
HALIFAX · YORKSHIRE
ESTABLISHED 1903

T.12

SOLUTION OF PROBLEMS IN STRENGTH OF MATERIALS

By S. A. Urry, B.Sc.(Eng.). 2nd Edition.
This up-to-date second edition is a practical textbook of Strength of Materials, intended for those students who prefer the study of specific problems to the more general approach of the orthodox textbook. Each chapter contains a number of fully worked-out problems, showing the derivation of essential formulae and their numerical application. The book will be invaluable to students preparing for the B.Sc. (Engineering) degree, and it fully covers the syllabuses of the Higher National Certificate in Mechanical Engineering and for the Associate Membership of the professional institutions. 20/- net.

PITMAN

Parker Street, Kingsway, London, W.C.2.
Tel. HOL 9791

OFFICIAL APPOINTMENTS

LONDON COUNTY COUNCIL. Architect's Department. Vacancies with good prospects for Engineering Assistants (up to £860) and Engineers, Grade III (up to £1,090) (under review) in :—(a) *Structural Engineering Division*—Extensive programme includes multi-storey flats, schools, offices, warehouses and other buildings, and, (b) *District Surveyors' Service*—in districts coinciding with one exception, with Metropolitan borough boundaries. Work mainly outside involving negotiations with Architects, engineers and surveyors, and supervision of works in progress. —Application form and particulars from the Architect (ref. AR/EK/48/57), The County Hall, S.E.1. (1611).

MIDDLESEX COUNTY COUNCIL. Required in County Architect's Department : Structural Engineering Assistants, Apt. I £575—£725 p.a. plus London Weighting (£30 p.a. 26 yrs. or over ; £20, 21-25 yrs. ; £10 under 21 yrs.). Established, pensionable staff, 5-day week. Must be neat detailers with knowledge of design in both reinforced concrete and structural steelwork. Prescribed conditions.—Application forms from County Architect, 1, Queen Anne's Gate Buildings, Dartmouth Street, Westminster, S.W.1 returnable by 12th November. (Quote W.162 SE.) Canvassing disqualifies.

SURREY COUNTY COUNCIL. Applications invited for appointment of Assistant Structural Engineer, Grade IV, £727.15s.—£907.2s.6d. p.a. plus £30 p.a. London Allowance. Qualified Civil or Structural Engineers, experienced in design and detailing in steel and/or reinforced concrete.—Full details, present salary and three copy testimonials to County Architect, County Hall, Kingston as soon as possible.

CLASSIFIED ADVERTISEMENTS

RATES

Per Word 8d.		
2 in.	Semi Display	£6 0s. 0d
3 in.	„	£8 10s. 0d.
4 in.	„	£11 0s. 0d.

SITUATIONS VACANT

CONSULTING Engineer, Westminster, requires Designer/Draughtsman experienced in structural steelwork and/or reinforced concrete for responsible position. Salary £1,000 p.a. and good prospects.—Write in confidence, stating age, qualifications and full details of experience, Box No. 0840, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

DESIGNER with at least 4/5 years' experience in reinforced concrete required for London professional office. Knowledge of steelwork an advantage. Degree and/or professional qualification desirable. Must be capable of working with minimum supervision and will be expected to attend Progress Meetings and deal directly with clients' representatives. The work is varied and offers scope for initiative. Five-day week.—Apply stating full particulars and salary required to Farmer & Dark, Romney House, Tufton Street, S.W.1.

DESIGNER required for R.C. specialist work. Five-day week, pension scheme, luncheon vouchers.—Apply in writing to Thomas Fletcher & Co. Ltd., 32, Old Burlington Street, London, W.1.

EXPERIENCED Structural Steelwork Designer required by Consulting Engineers with a good knowledge of light structures as well as conventional steel design. Five-day week, holiday arrangements honoured. Salary in accordance with experience. —Apply stating full details of experience and salary required to Alan Marshall & Partners, 73/74, High Holborn, W.C.1.

JUNIOR Engineers, Detailers and Draughtsmen required for varied work on steel and reinforced concrete structures. Five-day week. Salary £400—£700 according to age and experience. —Write to Leslie Turner & Partners, 6, Grove Road, Sutton, Surrey, or telephone Mr. K. Severn at VIGilant 0042.

REINFORCED Concrete Detailing Draughtsmen required for interesting and varied work. Five-day week. L.V.—Please write, stating age, experience and salary required to F. J. Samuely, 8, Hamilton Place, W.1.

REINFORCED Concrete Designers and Detailers required by London Consulting Engineers. Five-day week. Luncheon vouchers, pension scheme. Travelling expenses paid for interview.—Bylander & Waddell, 26, Old Burlington Street, London, W.1.

REINFORCED Concrete Detailers required. Salary up to £750 according to experience. Five-day week.—Hay and Barry, 29, Chesham Place, S.W.1. Sloane 9494.

REINFORCED CONCRETE DESIGN

Applications are invited from Senior Engineers capable of taking complete control of jobs and supervising the work of detailers and draughtsmen. R.C. structures of all types are dealt with, including shell roofs, prestressed work, etc. Lunch Vouchers are provided ; there is a pension scheme, and a five-day week is worked.

Write to the Chief Engineer, G.K.N. Reinforcements Ltd., 7, Oxford Road, Manchester, 1, marked " Personal." Applications will be treated in strict confidence, and if preferred you may telephone Wilmslow 2563 after office hours. Appointment can be arranged for any time of day or evening.

SENIOR Structural Draughtsmen required with first-class experience in steel-framed buildings. Responsible positions in interesting work which carry good pay.—Apply Johnson Structures Limited, Arnold Road, S.W.17.

CLASSIFIED ADVERTISEMENTS—continued

Opportunities for careers in Reinforced Concrete . . .

on the staff of

BRC

There are vacancies for Reinforced Concrete Designers in the London Office at 54 Grosvenor Street. Designs in prestressed and shell concrete are prepared at this office, in addition to a wide variety in normal Reinforced Concrete. Working conditions are excellent, the office being equipped with controlled heating and ventilation. Five day week — Canteen — Pension Scheme. Top rate salaries are paid to Designers, Designer-Detailers and Detailers in accordance with ability and experience. Openings available for graduates and men with H.N.C. Apprenticeship scheme available for students of good educational standard.

THE BRITISH REINFORCED CONCRETE ENGINEERING CO. LTD
STAFFORD
Chief Engineer: A. P. MASON, B.Sc., M.I.C.E., M.I.Struct.E., M.ASCE

M-W.841

STRUCTURAL Designer/Estimator required for progressive Company, London area. Age 30 to 35 years. Experienced in designing and estimating all types of structures. Preferably holding A.M.I.Struct.E. or at least H.N.C. Possibility right man being promoted to Chief Designer/Estimator on proving capabilities. Salary offered comparable with qualifications and experience. Five-day week, pension scheme.—Write stating age, nationality, qualifications and salary required to Box No. 0843, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

TERRESEARCH LTD. invite applications for the following vacancies. Civil and Structural Dept., Senior Engineer, fully qualified, experienced in Design and Construction, Investigations and Research (or with a desire to specialise in such matters). This is a first-class position of considerable responsibility for a leading man. The position offers outstanding opportunities for the successful applicant. Assistant Engineer qualified ; experience, similar duties and opportunities to the above. Ground Exploration and Soil Mechanics Dept. Engineers, qualified, experienced in Design and Construction, knowledge of Geology and Soil Mechanics and with a desire to specialise in this ever-widening and important specialised activity.—Applicants with full details of qualifications and experience to The Secretary, Terresearch Limited, Ruislip Road, Northolt, Greenford, Middx.

SITUATIONS REQUIRED

UNIVERSITY Graduate, six years' design and site experience in Structural Engineering requires responsible position anywhere. —Box No. 0842, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

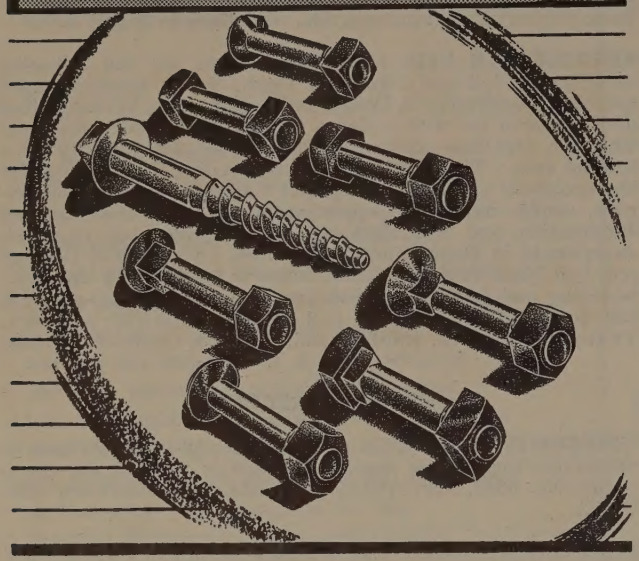
CHARTERED Structural Engineer (M.I.Struct.E.). Fifteen years' experience Chief Designer/General Manager specialising in production of large span buildings framed in Structural Precast Reinforced Concrete seeks position of similar responsibility. Excellent references. Min. salary £2,000 p.a. Box No. 0839, STRUCTURAL ENGINEER, 43a, Streatham Hill, S.W.2.

First portion of an Assembly Bay for Heavy Steel Fabrications.
Consultants :—F. R. Bullen and Partners.

JOSEPH WESTWOOD & CO. LTD.
NAPIER YARD, MILLWALL, LONDON, E.14. Telephone: EASt 1043

Bridge and Constructional Engineers. Manufacturers of Mechanical Grabs, Pressed Steel Troughing and Sheet Metal Equipment. Steel Stock Holders.

COOPER
NUTS and BOLTS



George Cooper & Sons

PROPRIETORS THOS. W. WARD LTD.

EFFINGHAM NUT & BOLT WORKS
SHEFFIELD

Phone : 41026 **Grams : 'COOPER'**

C.7

CLASSIFIED ADVERTISEMENTS—continued

FOR HIRE

LATTICE Steel Erection Masts (light and heavy), 30 ft. to 150 ft. high for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. ('Phone : SLOane 5259.)

15 TON Lorry Mounted Crane. 30ft.-80ft. boom with 15ft. fly jib available for short or long term hire any area. Arup & Arup Ltd., Colquhoun House, Broadwick Street, W.1. Gerrard 2708 or 3653.

FOR SALE

BENNIE Folding Machine for sale, 12 ft. × $\frac{1}{4}$ in. Motor driven Swing Beam Universal Folding, Rounding and Box Forming type. Max. lift of top beam 18$\frac{1}{2}$ in. Adjustment to bed and folding beam 8 in. Smallest trunk formed over beam 18 in. × 18 in. Largest tube formed 16 in. diameter. Gearbox drive with lever control to reversing friction clutches, operating all beams. Safety slipping clutch between gearbox and main drive shaft. Weight about 14 tons. Full details, illustrations etc. from F. J. Edwards Limited, 359, Euston Road, London (Euston 4681) or 41, Water Street, Birmingham, 3 (Central 7606).

WIEDEMANN Type R.4. hand-operated Turret Punching Machine with twelve stations for sale. Steel plate construction. Fitted with punches and dies from $\frac{1}{4}$ in. to 1$\frac{1}{4}$ in. diameter. Capacity $\frac{3}{8}$ in. dia., holes through $\frac{3}{16}$ in. thick, or 1$\frac{1}{4}$ in. dia., through 14 s.w.g. Depth of gap to frame 24 in. Photo etc. from F. J. Edwards Ltd., 359 Euston Road, London, N.W.1.

FOR Sale—12in. Transit Theodolite complete in case with tripod and 14in. Dumpy level in case complete with tripod and staff. Price £75, Woolsey & Co., Surveyors, Victoria House, Southampton Row, W.C.1., Holborn 1866.

TUITION

GUARANTEED COACHING for Inst. Struct. Engrs., Inst. Civ. Engrs., Inst. Mun. Engrs., etc. Study at home under highly qualified tutors with most successful school. Also courses in all aspects of Building, Engineering, Draughtsmanship, etc.—Write for free book : International Correspondence Schools Ltd., Dept. CL, 23, Kingsway, London, W.C.2.

INDEX TO ADVERTISERS

	Page
Arrol, Sir William & Co. Ltd.	3
Booth, John & Sons (Bolton) Ltd.	12
British Columbia Lumber Manufacturers Assoc.	6
British Oxygen Gases Ltd.	7
British Reinforced Concrete Engineering Co. Ltd., The	Cover IV
Broom & Wade Ltd.	23
Butterley Co. Ltd., The	21
Butters Bros. & Co. Ltd.	16
Cement Marketing Co. Ltd.	13
Cementation Co. Ltd.	22
Concrete Development Co. Ltd.	18
Consolidated Pneumatic Tool Co Ltd.	39
Cooper, George & Sons	46
Dawnays Ltd.	Cover III
Denison, Samuel & Son, Ltd.	36
Dickens, Stuart B. Ltd.	5
Dow-Mac (Products) Ltd.	30
Douglas, Robert M. (Contractors) Ltd.	26
Expanded Metal Co., The	25
Fibreglass Ltd.	41
Findlay, Alex & Co. Ltd.	14
Franki Compressed Pile Co. Ltd.	15
Ground Explorations Ltd.	40
Hills (West Bromwich) Ltd.	10
Howard Farrow Ltd.	14
Johnson, Richard & Nephew Ltd.	2
Jones, T. C. & Co. Ltd.	9
Lafarge Aluminous Cement Co. Ltd.	Cover II
Laing, John & Son Ltd.	32
Lesser, J. E. & Sons Ltd.	40
Lincoln Electric Co. Ltd.	37
McCall Macalloy Ltd.	42
Mellowes & Co. Ltd.	34
Murex Welding Processes Ltd.	28
Peirson & Co. Ltd.	4
Pitman	44
Pre-piling Surveys Ltd.	42
Pressure Piling Company (Parent) Ltd., The	20
Pynford Ltd.	38
Ruberoid Ltd.	8
Simplex Concrete Piles Ltd.	36
Skinningrove Iron Co. Ltd.	11
South Durham Steel & Iron Co. Ltd.	19
Stent Precast Concrete Ltd.	34
Stramit Boards Ltd.	35
Tentor Bar Co. Ltd.	33
Tileman & Co. Ltd.	29
Town, Fredk. & Sons Ltd.	43
Trianco Ltd.	22
United Coke & Chemicals Co. Ltd.	38
United Steel Co. Ltd.	27
Ward, Thos. W., Ltd.	1
Westwood, Joseph & Co. Ltd.	45
Wood, Edward & Co. Ltd.	24
Wright, Anderson & Co. Ltd.	17
Yorkshire Hennebique Con. Co. Ltd., The	43

DAWNAYS
STEELWORK

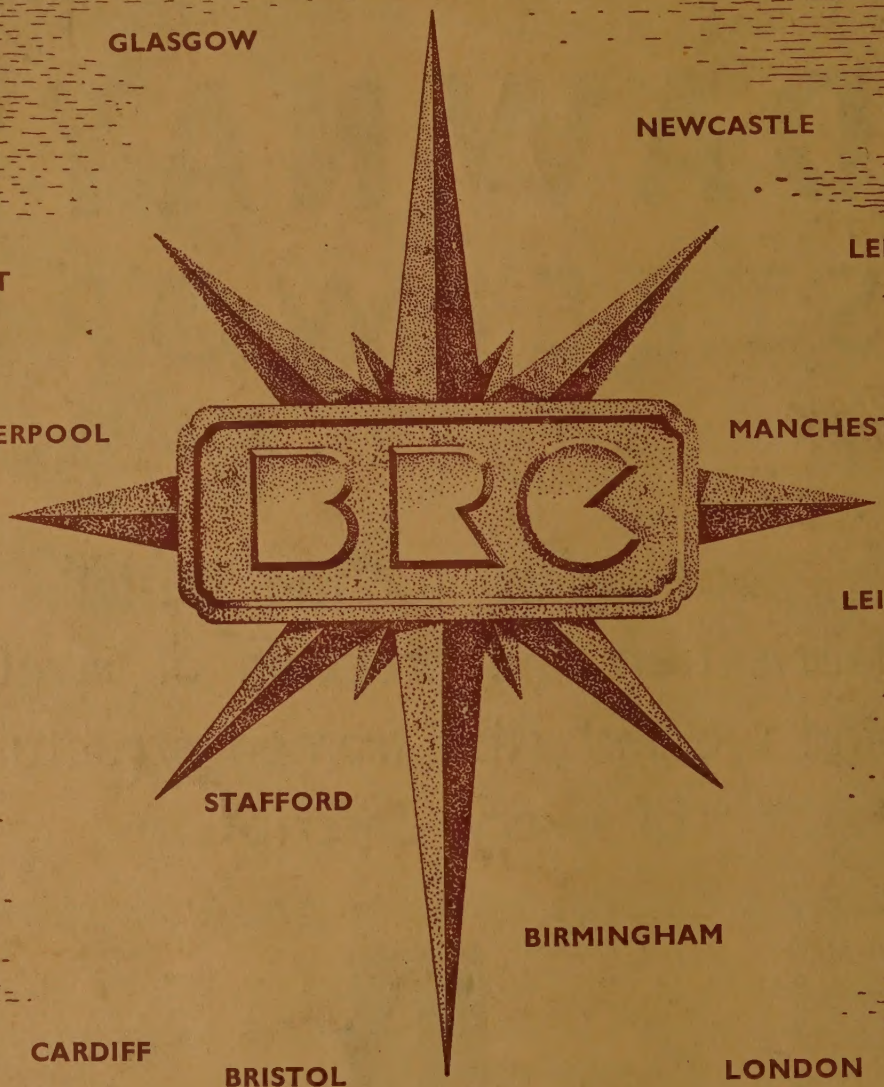
Specialists in the design, fabrication and erection of riveted and welded steel-framed structures of every description

DAWNAYS LIMITED
BRIDGE & STRUCTURAL ENGINEERS

HEAD OFFICE: **STEELWORKS RD., LONDON, S.W.11** : Telephone **BATTERSEA 2525**

King's Dock Works **SWANSEA 50471**	East Moors Works **CARDIFF 23336**	54 Victoria St., London, S.W.1 **VICTORIA 1541**	Bridge Rd. Works **WELWYN GDN. 3913**	Thorpe Works **NORWICH**
Waterloo Bldgs., London Rd. **SOUTHAMPTON 22474**	40 Park Road **PETERBOROUGH 4567**	Great Field Lane, Marfleet **HULL 75134-5**	22 High Street **ROMFORD 2106**	7 The Close **NORWICH 23141**

Cables and Telegrams "**DAWNAYS, LONDON**"—Code Bentley's 2nd.



Specialists in Reinforced Concrete Design and Suppliers of Reinforcement, with Design and Branch Offices strategically placed throughout the British Isles

REINFORCED CONCRETE IS CONSTRUCTION AT ITS BEST

There are vacancies for experienced engineers in several of our design offices.

The British Reinforced Concrete Engineering Co. Ltd., Stafford

M-W.791